

CUMULATIVE HYDROLOGIC IMPACT ASSESSMENT (CHIA)

BOOK CLIFFS AREA II

Canyon Fuel Company
Soldier Canyon Mine
C/007/0018

Canyon Fuel Company
Dugout Canyon Mine
C/007/0039

Carbon County, Utah

June 24, 2005

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INTRODUCTION

I. INTRODUCTION

The Soldier Canyon and Dugout Canyon Mines are located in the Book Cliffs Coal Field, approximately 12 miles northeast of Price, Utah (Figure 1). The Book Cliffs form a rugged, southerly facing escarpment that separates the Uintah Basin to the north, from the San Rafael Swell to the south.

Elevations along the Book Cliffs range from approximately 5,000 to 9,000 feet. Annual precipitation varies from 20 inches at the highest elevations to 8 inches along the Price River, just downstream of the town of Wellington (Figure 2). The climate classification for the Book Cliffs area is mid-latitude steppe to semi-arid desert.

Vegetation varies from the sagebrush/grass community type at lower elevations to the Douglas fir/aspen community at higher elevations. Other vegetative communities include mountain brush, pinyon-juniper, pinyon-juniper/sagebrush, and riparian. The primary uses of these communities are wildlife habitat and livestock grazing.

The age of rocks that outcrop in the Book Cliffs ranges from Upper Cretaceous to Quaternary. The rock record reflects an overall regressive sequence in depositional environments from marine on the valley floor, and at the base of the cliffs (Mancos Shale); up through littoral, and lagoonal (Starpoint Sandstone and Blackhawk Formation); to fluvial (Castlegate Sandstone, Price River Formation and North Horn Formation), and lacustrine (Flagstaff Formation and Green River Formation). The Colton Formation is a fluvial-deltaic sequence separating the Flagstaff and Green River deposits. Oscillating depositional environments within the overall regressive Cretaceous trend are represented by members of the Blackhawk Formation, which is the major coal-bearing unit within the Book Cliffs Coal Field. The Starpoint and Flagstaff Formations both thin eastward; the Starpoint pinches out near Fish Creek, and the Flagstaff near the headwaters of Cow Canyon (see Plate 1 for stream locations).

Surface runoff from the Book Cliffs area flows into the Price River drainage basin of south-central Utah (Figure 2). The drainages around Scofield Reservoir and Soldier Summit comprise the headwaters of the Price River. The river flows southeasterly and joins the Green River approximately 15 miles north of the town of Green River, Utah. Water quality is good in the mountainous headwater tributaries, but deteriorates rapidly after the river leaves Price Canyon and flows across the Mancos Shale. The Mancos typically has low permeability, is easily eroded, and contains large quantities of soluble salts. Total dissolved solids (TDS) levels of 3,000 mg/L and sulfate concentrations over 1,000 mg/L are common in the lower reaches of the Price River.

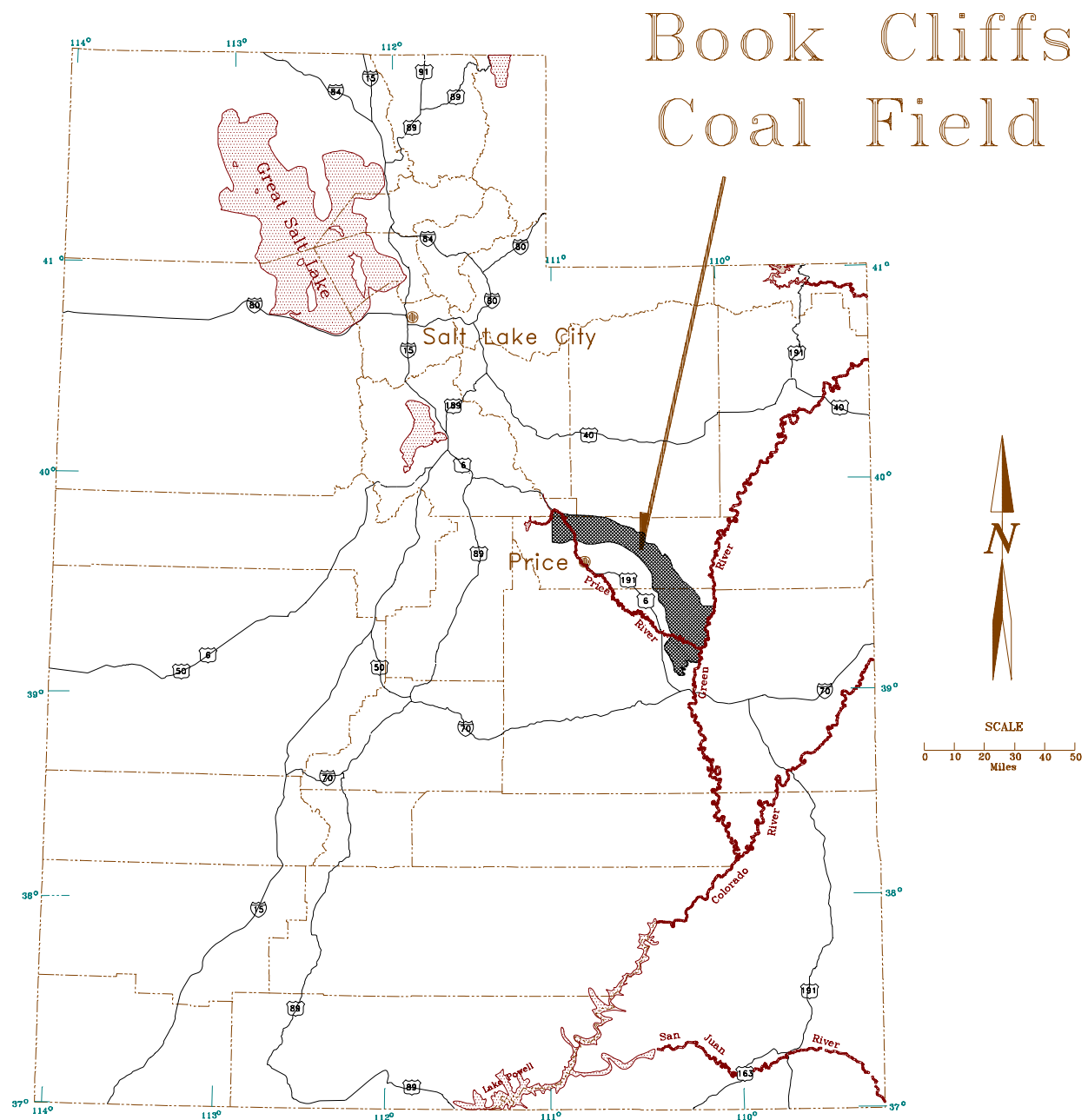


Figure 1 – Location of Book Cliffs Coal Field in Utah

This cumulative hydrologic impact assessment (CHIA) is a findings document involving an assessment of the cumulative impact of all anticipated coal-mining operations on the hydrologic balance within the Cumulative Impact Area (CIA). Anticipated coal mining operations are Canyon Fuel Company's (formerly Soldier Creek Coal Company) Soldier Canyon and Dugout Canyon Mines, and a portion of Andalex Resource Inc.'s Centennial Project Mine.

INTRODUCTION

The CHIA is not a determination of whether or not each coal mining operation is designed to prevent material damage beyond its respective permit boundary when considered individually, rather it is a determination of whether or not there will be material damage resulting from the cumulative effects of adjoining mines outside the individual permit boundaries. This report complies with federal legislation passed under the Surface Mining Control and Reclamation Act (SMCRA, Public Law 95-87) and subsequent Utah and federal regulatory programs under R645-301-729 and 30 CFR 784.14(f), respectively.

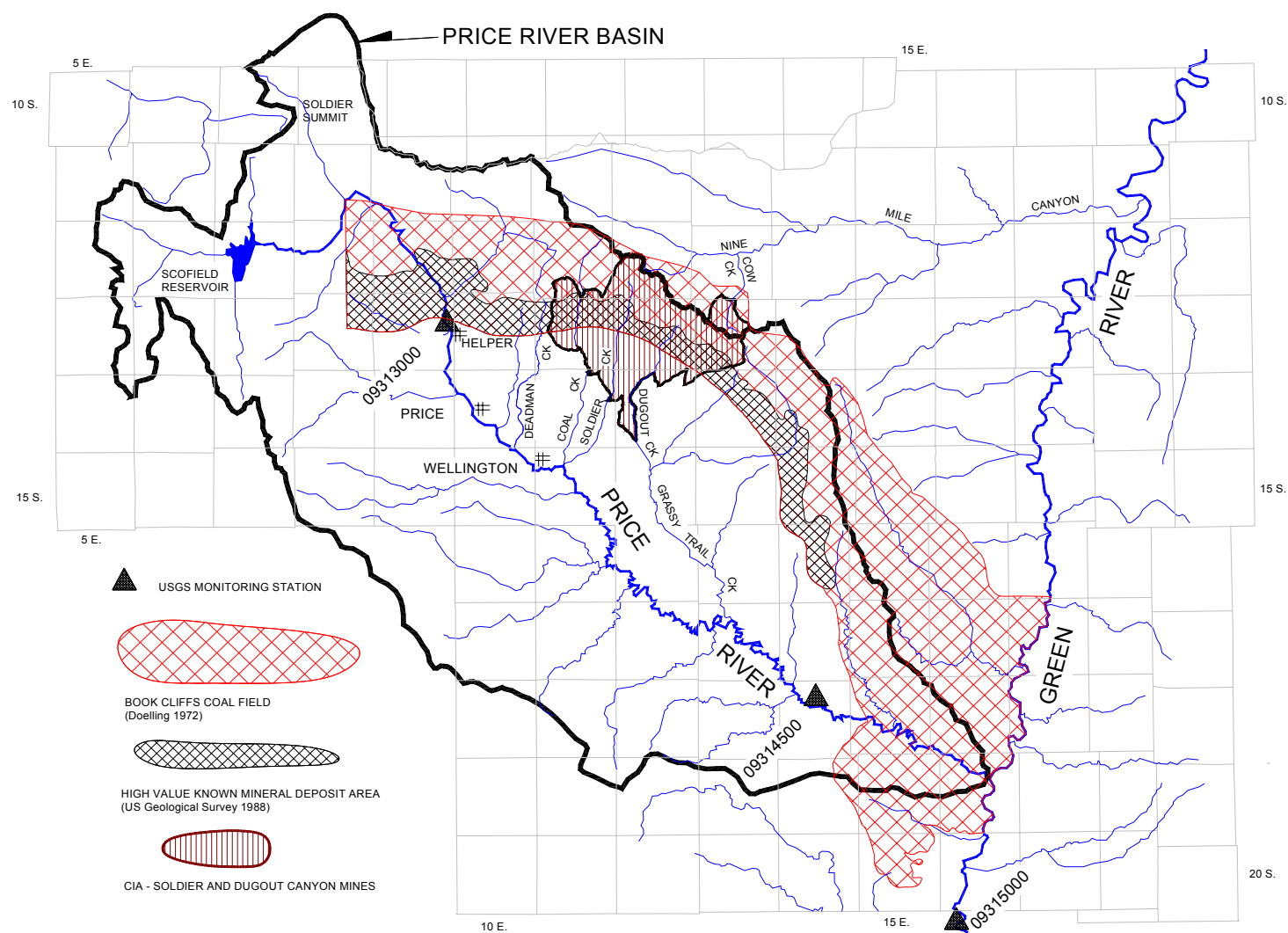
The objectives of a CHIA document are to:

1. Identify the Cumulative Impact Area (CIA). (Part II)
2. Describe the hydrologic system - including geology, identify hydrologic resources and uses, and document baseline conditions of surface and ground water quality and quantity (Part III)
3. Identify hydrologic concerns. (Part IV)
4. Identify relevant standards against which predicted impacts can be compared; define Material Damage. (Part V)
5. Estimate probable future impacts of mining activity with respect to the parameters identified in 4. (Part VI)
6. Assess Material Damage potential. (Part VII)
7. Make a statement of findings. (Part VIII)

The Division originally prepared a CHIA in 1984 for the Sage Point-Dugout Canyon Mine that Sunoco Energy Development Company permitted but never developed (The current Dugout Canyon Mine permit area includes roughly the western half of this old Sage Point-Dugout Canyon permit area). The Division updated the CHIA to add the Soldier Canyon Mine on February 4, 1987, and again on October 7, 1996 to accommodate the addition of the Soldier Canyon Alkali lease. The Division prepared a new CHIA for both the Soldier Canyon and Dugout Canyon Mines on March 16, 1988, which they updated on March 30, 2000 to include the addition of federal lease U-07064-027821 to the Dugout Mine. The Division is updating the CHIA at this time to include the addition of SITLA Lease ML-42649 to the Dugout Canyon Mine.

INTRODUCTION

Figure 2 – Book Cliffs Coal Field and Price River Basin



II. CUMULATIVE IMPACT AREA (CIA)

The Book Cliffs Area II Cumulative Impact Area (CIA) is shown on Plates 1, 2, and 3 and Figures 2 and 3. The CIA is the area within which actual and anticipated coal mining activities may interact to affect the surface and ground water. The CIA is determined based on anticipated mining activities, knowledge of surface and ground water resources, and anticipated impacts of mining on those water resources.

The CIA contains approximately 62,630 acres and includes the easternmost part of Andalex Resources', Centennial Project, the Soldier Canyon Mine permit area, the Dugout Canyon Mine permit area (including SITLA coal tract ML-42649), and the Dugout Mine's waste-rock disposal site. The CIA boundary mainly follows surface-drainage divides, but it lies along the bottoms of drainage channels around most of the waste-rock disposal area and part of the Cow Canyon drainage (Plate 1).

The Soldier Canyon permit area consists of approximately 6,625 acres and includes a topsoil storage area (includes topsoil piles for Soldier and Dugout) and a sewage lagoon located outside the mine pads and portal area. The Dugout Canyon Mine permit area is approximately 9,471 acres, including the waste-rock disposal area, which is approximately 30 acres. The portion of the Centennial Project included in the CIA is entirely underground. Coal, Soldier, Dugout, Pace, Rock, and Cow Creeks are the major drainages in the CIA, and Pine and Fish Creeks are major tributaries to Soldier Creek.

SCOPE OF MINING

Coal Canyon

Initial prospecting took place along Coal Creek in 1906. From 1946 to 1958, the two Knight Ideal Mines produced 1.7 million tons of coal from the Gilson Seam (Doelling, 1972). Plate 30 of the Centennial Project MRP shows part of the Knight Mine workings.

Approximately 320 acres of the Soldier Canyon Mine permit area are on the west side of Coal Creek, north of Hoffman Creek (Plate 1), but no mining is planned in this western section of the permit area or under Coal Creek. Mining in the Rock Canyon and Gilson Seams is projected beneath some tributary drainages east of Coal Creek. Coal will be produced by room-and-pillar mining methods, with some areas to be second-mined. Canyon Fuel Company has no plans to mine the Sunnyside Seam beneath the Coal Creek drainage.

The portals for the Centennial Project are located in Deadman Canyon, approximately 2 miles west of the Soldier Canyon Mine permit area boundary. Most of the Centennial Project permit area, including all disturbed areas, drains to the Price River by way of Deadman Creek; however, the eastern part of the Centennial Project permit area lies within the Book Cliffs Area II CIA, in the drainages of Straight Canyon and Hoffman Creek, two tributaries to Coal Creek. A large section of the Gilson Seam and smaller portions of the Lower Sunnyside Seam have

already been mined under this area, with overburden thickness going from minimal, where mining was done near the outcrops, to 800 feet. In this eastern area longwall mining is planned for one small panel in the Gilson Seam under Hoffman Creek and for two small panels in the Aberdeen Upper AA@ Seam under Straight Canyon. Room-and-pillar mining in the Lower Sunnyside Seam under both the Straight Canyon and Hoffman Creek drainages is planned as part of the development of the Centennial Project, but actual mining of this seam will depend on market demand. Overburden thicknesses are from 400 to 1,200 feet.

The Book Cliffs Area I (Centennial Project) and Book Cliffs Area II (Soldier Canyon - Dugout Canyon-Centennial Project) CIAs overlap in the Coal Creek drainage. However, it is not probable that any of the mine operations will cause measurable or noticeable impacts to the hydrologic balance of this drainage, either individually or cumulatively. There will be no surface facilities for any mine in the Coal Creek drainage, no operation will cause subsidence beneath, or immediately adjacent to, Coal Creek; and other surface effects within this drainage should be insignificant to non-existent.

Soldier Canyon

A mine in Soldier Canyon was opened in 1906, but little coal was produced until 1935, when Premium Coal Company became the operator. Premium operated the mine from 1935 until 1972. Production during that period was approximately 1.2 million tons (Doelling, 1972).

In September of 1974, California Portland Cement Company purchased the property and after making improvements resumed production on June 15, 1976.

On September 5, 1985, assets were transferred to Sunedco Coal Company, a subsidiary of Sun Company, Inc. Subsequently the mining equipment and facilities were transferred to a newly incorporated subsidiary, Soldier Creek Coal Company, with ownership of the federal and state coal leases held by two affiliate companies, Sunedco Coal Company and Sunoco Energy Development Company (Sunedco). Sunedco Coal Company expanded the Soldier Canyon Mine permit area to incorporate adjacent acreage that had not been included in Sunoco Energy Development Company=s Sage Point-Dugout Canyon Mine permit. (A permit for Sunoco Energy Development Company=s Sage Point-Dugout Canyon Mine was approved by OSM in May 1984 (UT-0041) and by Utah Division of Oil, Gas and Mining (The Division) June 5, 1984, (ACT/007/009) but poor coal markets dictated a delay in developing that mine.)

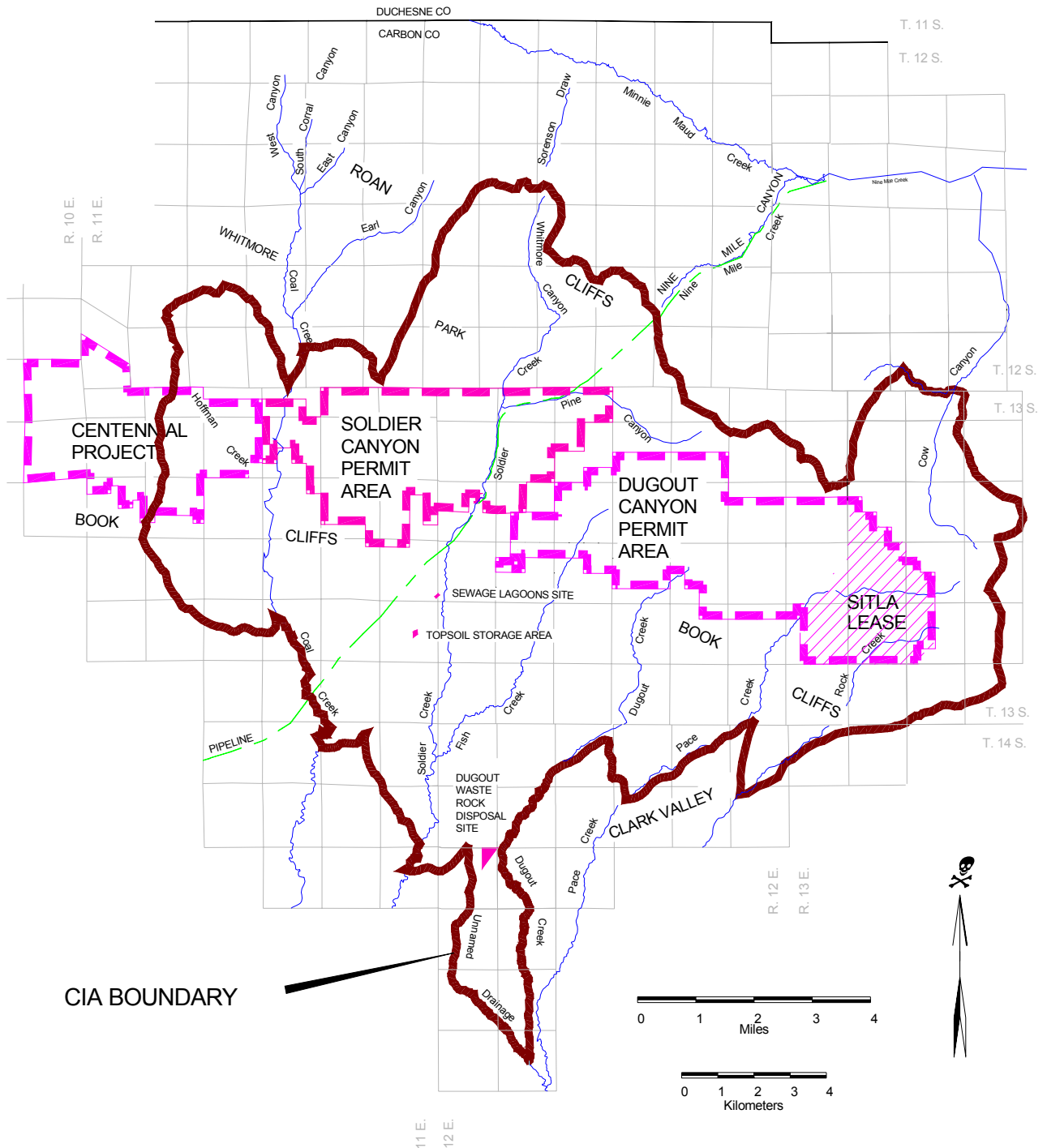


Figure 3 – Cumulative Impact Area (CIA)

A corporate reorganization by Sun Oil Company, Inc. merged Sunedco Coal Company and Sunoco Energy Development Company into Sage Point Coal Company, which became the

sole shareholder of Soldier Creek Coal Company. Coastal States Energy Company purchased all stock of Sage Point Coal Company and Soldier Creek Coal Company on September 16, 1993.

In 1996, Coastal States Energy Company and all of its subsidiaries were merged into a newly formed, limited-liability company, Canyon Fuel Company, LLC. Then on December 20, 1996 Canyon Fuel Company, LLC was sold to ARCO Uinta Coal Company (a subsidiary of Atlantic Richfield Company) and Itochu Coal International, Inc. (a subsidiary of Itochu Corporation). Arch Western Resources, LLC purchased ARCO Uinta's 65% interest on March 22, 1998 and became 100% owners on July 14, 2004. At the time this CHIA was prepared Canyon Fuel Company owned and operated the Soldier Canyon and Dugout Canyon Mines.

Coal production at the Soldier Canyon Mine, 1985 through 1999, is summarized in Table 1. Maximum annual production was 1.2 million tons in 1990. Production projections have been as high as 1.75 million tons per year, and the current air quality permit allows coal production of up to 3.5 million tons. The mine went into temporary cessation in 1998.

Existing underground workings at the Soldier Canyon Mine are approximately 2 miles in width and extend 1.5 miles down dip. Mining has been in the Rock Canyon and Sunnyside Seams. Addition of the Alkali lease area allows mining in the Rock Canyon Seam to continue approximately 1.5 miles farther to the west and allow future access to the Gilson Seam. There are no plans to mine the Sunnyside Seam in the Alkali tract. Mining in the Soldier Canyon Mine has been by the room and pillar method.

Dugout Canyon

Beginning in 1925, the Red Glow Mine was developed by D. J. Collins in the Gilson Seam on the east side of Dugout Canyon. The west side of the canyon was first mined in 1952 by E.S.O. Coal Company, in the Rock Canyon Seam. The Knight Ideal Coal Company mined both seams on both sides of the canyon from 1958 to 1964. 1.3 million tons of coal were extracted using the room-and-pillar method and partial pillar recovery. Maps of these workings are on Plate 5-1 of the Dugout Canyon Mine MRP.

The mine facilities and rights to the coal changed hands several times between 1964 and 1998, but no coal was extracted during this period. Pacific Gas and Electric (PG&E), through its subsidiary Eureka Energy Company, submitted a Mining and Land Use plan for the Sage Point-Dugout Canyon Mine to the BLM and USGS in 1976 and carried out limited exploration through existing portals in 1979. In December 1980, Eureka Energy Company submitted a Permit Application Package (PAP) and MRP to the Division under the approved Utah State program. In May 1982 Sunedco purchased Eureka Energy Company's Sage Point - Dugout Creek properties and again limited exploration through existing portals was done. Permits to mine coal were approved by both OSM and the Division in 1984, but in 1987 the federal permit terminated due to lack of development or construction, the state permit was revoked, and mine plan approval canceled.

After both the Eureka and PG&E explorations, the portals were resealed with earthen fill.

Soldier Creek Coal Company reopened four portals, two on the east and two on the west, in 1995. The east portals were resealed, but the west portals were still open as of early 1998, with fencing providing safety, security, and access control. The Dugout Canyon Mine was constructed in 1998, and 168,000 tons of coal was produced from the Rock Canyon Seam that year.

Both the Gilson and Rock Canyon Seams have been previously mined in Dugout Canyon, and in the Dugout Canyon Mine they are the only seams sufficiently developed to allow for economic mining; however, multiple seam mining will be limited to the vicinity of Dugout Canyon. The Gilson Seam is generally not of mineable thickness west of Dugout Canyon. East of Dugout Canyon the sulfur content of the Rock Canyon coal increases and renders it unmarketable. In addition, interburden between the two seams thins east of the canyon, making multiple seam mining difficult, dangerous, and uneconomical. The mine entry is in the Rock Canyon Seam, and a rock-slope is planned for access down to the Gilson Seam. Projected mining in the Dugout Canyon Mine will extend approximately 5 miles southeast-to-northwest and up to 1.5 miles under the Book Cliffs: if the SITLA tract is mined from the Dugout Canyon Mine, the mine will be close to 7 miles in length.

Pace Canyon Mine

The Pace Canyon Mine, once known as the Snow Mine, was reported to have operated in 1906 and from 1932 to 1940, but may have actually never been more than a prospect (Doelling, 1972). It is located in Section 30, T. 13 S., R. 13 E., at the southeast edge of federal lease U-07064-027821. According to Canyon Fuel Company the Spring Canyon and Pace Canyon Mines are considered for preservation by Utah State Historic Preservation Office (SHPO), but were ineligible for nomination to the National Register of Historic Places.

Canyon Fuel Company, LLC, added a fan and related facilities in Pace Canyon in 2005 (see Plate 1 for the location). The disturbed area encompasses about 2.8 acres. The Pace Canyon facilities consist of an access road, fan, topsoil storage areas and hydrologic routing structures. The site contains two point source discharge sites that are regulated under the Utah Pollutant Discharge Elimination System program (UPDES) managed by the Utah Division of Water Quality. Some of the mine water currently discharged from the Dugout Mine will be discharged from the Pace Canyon fan portal directly to Pace Creek.

Other

The Spring Canyon Mine in Section 21, T. 13 S., R. 12 E. operated from 1906 to 1910 (Doelling, 1972). This is within the Dugout Canyon Mine permit boundary, in the canyon of what is now called Fish Creek.

The Rock Canyon Mine is located along Rock Creek in Section 32, T. 13 S., R. 13 E., was prospected in 1906 and produced 93,000 tons from the Rock Creek and Sunnyside Seams between 1952 and 1960 (Doelling, 1972).

TABLE 1

Annual Coal Production, Water Discharge, and Water Consumption at the Soldier Canyon Mine 1985 to 1999

YEAR	Coal Production From Annual Reports (tons)	Water Discharge From DMRs (gallons)	Water Discharge From Annual Reports (gallons)	Water Discharge Coal Production (gallons/ton)	Coal Moisture and Evaporation From Annual Reports (gallons)	Water Consumption Coal Production (gallons/ton)
1985	675,982	11,406,000	39,123,000	17 to 58	11,987,000	18
1986	558,781	85,714,000	88,397,000	153 to 158	9,798,000	18
1987	468,465	52,560,000	54,444,000	112 to 116	7,796,000	17
1988	(not available)	(not available)	(not available)		(not available)	
1989	1,112,016	140,768,000	140,526,000	126	13,262,000	12
1990	1,207,432	241,630,000	241,630,000	200	14,185,147	12
1991	1,060,996	254,248,688	302,059,000	240 to 285	19,552,000	18
1992	422,345	283,300,000	265,061,000	671 to 628	9,941,000	24
1993	512,621	178,105,000	172,139,000	347 to 336	(not available)	
1994	583,696	174,005,000	144,181,000	298 to 247	(not available)	
1995	480,895	131,843,000	128,920,000	274 to 268	(not available)	
1996	977,000	125,596,000	89,677,620	128 to 92	(not available)	
1997	1,150,000	139,856,000	110,993,020		(not available)	
1998	574,000	47,688,000	44,172,000		(not available)	

CUMULATIVE IMPACT AREA

Book Cliffs Area II

TABLE 1 Annual Coal Production, Water Discharge, and Water Consumption at the Soldier Canyon Mine 1985 to 1999						
	- no production after October		- no discharge after May			
1999	0	No discharge	No discharge		(not available)	

TABLE 2 Annual Coal Production, Water Discharge, and Water Consumption at the Dugout Canyon Mine 1998 to 2003			
YEAR	<i>Coal Production</i> From Annual Reports (tons)	Water Discharge From DMRs (gallons)	Water Discharge Coal Production (gallons/ton)
1998	168,000	0	0
1999	828,000	0	0
2000	498,000	0	0
2001	1,981,000	0	0
2002	2,080,000	55,915,635	26.9
2003	2,941,000	36,853,703	12.5

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Book Cliffs Area II

CUMULATIVE IMPACT AREA

III. HYDROLOGIC SYSTEM and BASELINE CONDITIONS

Elevations range from less than 6,000 feet to approximately 8,500 feet in the CIA. Predominant features that exist in the Book Cliffs Area II CIA are cliffs, narrow canyons, valleys, and pediments. Drainage in the CIA is characterized by perennial, ephemeral, and intermittent streams that drain generally north or south from the drainage divide at the top of the Book Cliffs. Soldier and Coal Creeks are perennial streams, with headwaters that originate at elevations of 7,500 to 8,000 feet. The Mount Bartles USGS topographic quad indicates the streams in the main and right forks of Cow Canyon are perennial. Headwater areas in Pine Canyon are described as appearing to be perennial in the Soldier Canyon Mine MRP (p. 7-32). Fish, Dugout, Pace, and Rock Creeks are major intermittent drainages, although Dugout and Fish Creeks are described in the Dugout Canyon Mine MRP as perennial in the vicinity of the proposed Dugout Mine, based on observations and water monitoring data.

GEOLOGY

The geology of the Book Cliffs Area II CIA consists of stratigraphic units of consolidated rock ranging in age from Late Cretaceous to Tertiary (Eocene), as shown in Figure 4. The oldest exposed rocks include members of the Mancos Shale. The Mesaverde Group overlies the Mancos Shale and consists of the Starpoint Sandstone, Blackhawk Formation, Castlegate Sandstone, and Price River Formation. Overlying the Mesaverde Group are the North Horn Formation, Flagstaff Limestone, Colton Formation, and Green River Formation that, in this area, constitute the Wasatch Group of Paleocene to Eocene age. The Eocene Green River Formation is the uppermost consolidated formation in the CIA. Unconsolidated deposits formed by weathering and erosion exist as soils in Whitmore Park, as terrace deposits and gravels along canyon streams, and as pediments at the base of escarpments.

There are no major disconformities in the area. The formations were tilted northeastward in response to the rise of the San Rafael Swell and Socally and Farnam anticlines. The strike of the area changes from N 84° W on the west to N 65° W on the east. The dip ranges from 6° to 12° and averages 8° northeast.

Fracturing is generally parallel to the strike of the Book Cliffs escarpment, and hence parallel to the strike of the strata. Fracturing appears to be the result of isostatic adjustment and general upwarping associated with the San Rafael Swell and subsequent erosional, tectonic and orogenic events. Measurements taken in the Soldier Canyon Mine show face cleat direction is within a few degrees of the strike of the coal bed.

HYDROLOGIC SYSTEM

System	Series	Stratigraphic unit		Thickness (feet)	Description		
TERTIARY	Eocene	Green River Formation		—	Greenish gray and white claystone and shale, also contains fine-grained and thin-bedded sandstone. Shales often dark brown containing carbonaceous matter. Full thickness not exposed.		
		Colton Formation	Wasatch Formation	300-2,000	Colton consists of brown to dark red lenticular sandstone, shale and siltstone, thins westwardly and considered a tongue of the Wasatch.		
	Paleocene	Flagstaff Limestone		3,000	Wasatch predominantly sandstone with interbedded red and green shales with basal conglomerate. Found in east part of field and equivalent to Colton and Flagstaff in west.		
		0- 500		Flagstaff mainly light gray and cream colored limestones, variegated shale, and fine-grained, reddish brown, calcareous sandstone.			
CRETACEOUS	North Horn Formation		350-2,500	Gray to gray green calcareous and silty shale, tan to yellow-gray fine-grained sandstone and minor conglomerate. Unit thickens to west. Light gray to cream-white friable massive sandstone and subordinate buff to gray shale that exhibits light greenish cast. Contains minor conglomerate and probably represents lower part of North Horn, only present in east part of field.			
	<i>MINOR COAL</i>						
	Danian	Tuscher Formation		0- 200			
	Maestrichtian						
	Campanian	Mesaverde Group	Price River Formation <i>MINOR COAL</i>	500-1,500	Yellow-gray to white, medium-grained sandstone and shaley sandstone with gray to olive green shale. Contains carbonaceous shale with minor coal and thickens along east edge of field.		
			Castlegate Sandstone <i>MINOR COAL</i>	100- 500	White to gray, fine- to medium-grained, argillaceous massive resistant sandstone thinning eastwardly with subordinate shale. Carbonaceous east of Horse Canyon but coal is thin and lignitic.		
			Blackhawk Formation <i>MAJOR COAL SEAMS</i>	600-1,100	Cyclical littoral and lagoonal deposits with six major cycles. Littoral deposits mainly thick-bedded to massive cliff-forming yellow-gray fine- to medium-grained sandstone, individual beds separated by gray shale. Lagoonal facies consist of thin- to thick-bedded yellow-gray sandstones, shaley sandstones, shale and coal. Coal beds form basis of Book Cliffs coal field. Unit thins eastward grading into the Mancos Shale.		
			Star Point Sandstone	0- 580	Yellow-gray massive medium- to fine-grained littoral sandstone tongues projecting easterly separated by gray marine shale tongues projecting westerly.		
			Masuk Tongue	Mancos Shale	4,300-5,050	Gray marine shale, locally heavily charged with carbonaceous material, slightly calcareous and gypsiferous, nonresistant forming flat desert surfaces and rounded hills and badlands. Separated mainly to the west into tongues by westward projecting littoral sandstone which eventually grade into shale. Sandstones are fine- to medium-grained, yellow-gray to tan and medium-bedded to massive and cliff forming.	
	Emery Sandstone						
	Garley Canyon Sandstone						
	Blue Gate Shale						
	Turonian	Ferron Sandstone <i>MINOR COAL</i>					
		Tununk Shale					
	Cenomanian	Dakota Sandstone					2- 126

HYDROLOGIC SYSTEM

Two small faults have been mapped in the CIA (Anderson, 1983). One fault, with a few feet of down-to-the-north displacement, was found between the right and left forks of Fish Creek (Sec. 20 and 21, T. 13 S., R. 12 E.). It strikes roughly east-west and may be related to slumping or breaking-away of rock from the escarpment. A northwest-southeast striking fault, with approximately twenty-five feet of down-to-the-southwest displacement, was mapped east of the Dugout permit area in Sec 12, T13 S., R 12 E. and Secs. 7 and 18, T. 13 S., R. 11 E. There are numerous small, superficial faults, which appear to be related to collapse in burned coal zones (Dugout Canyon Mine MRP).

Major coal seams, and therefore mining operations, are restricted to the Blackhawk Formation. Data indicate that five coal zones have lateral consistency in the vicinity of the Soldier Canyon and Dugout Canyon Mines. From top to bottom, they are the Sunnyside, Rock Canyon, Fish Creek, Gilson, and Kenilworth Seams. The Sunnyside, Rock Canyon and Gilson Seams contain minable reserves. Overburden thickness ranges from approximately 100 feet under Soldier and Dugout Creeks to over 2,000 feet at the north edge of the permit areas.

The Sunnyside and Rock Canyon Seams have been mined by Soldier Creek Coal Company, and mining in the Rock Canyon and Gilson Seams is planned for the Alkali tract. The Dugout Canyon Mine has mined the Rock Canyon Seam west of Dugout Canyon, and the Gilson Seam east of the canyon.

Roughly the eastern half of the Centennial project is within the Book Cliffs Area II CIA. Longwall mining is planned for the Gilson and Aberdeen Upper AA@ (Castlegate) Seams and continuous mining for the Lower Sunnyside Seam in that portion of the Centennial Project Mine. Overburden thickness ranges from 400 to 1,200 feet. A large area of the Gilson Seam and smaller portions of the Aberdeen and Sunnyside Seams have already been mined in this area with overburden thickness up to 800 feet.

HYDROLOGY

Ground water

The Blackhawk Formation, Castlegate Sandstone, Price River Formation, North Horn Formation, Flagstaff Limestone and Quaternary deposits all contain potential reservoirs or conduits for ground water in the CIA. Reservoir lithologies are predominately sandstone and limestone. Sandstone reservoirs occur where there is sufficient intergranular porosity and permeability in lenticular fluvial-channel and tabular overbank deposits, whereas limestone reservoirs have developed through dissolution and fracturing of tabular lacustrine deposits. Shale, siltstone, and cemented sandstone beds act as aquatards or aquacludes to impede ground-water movement. The Mancos Shale is a regional aquaclude that limits downward flow within the CIA. More localized aquatards occur within the North Horn, Price River, Castlegate and Blackhawk Formations. Ground water in the CIA occurs under both confined and unconfined conditions, as is typical of ground water throughout the Price River basin.

Average annual precipitation ranges from approximately 8 inches along the lower reaches

of Soldier and Dugout Creeks, to 16 inches in the headwater regions (Mundorff, 1972, Plate 2). Recharge has been estimated to be 3% to 8% (Danielson and Sylla, 1983) and 9% (Waddell and others, 1986) of the average annual precipitation for the Wasatch Plateau and Book Cliffs coal fields. Snowmelt provides most ground-water recharge. In the Book Cliffs the recharge rate is generally greatest where limestones of the Flagstaff Formation are exposed as dip-slopes at the higher elevations.

Once recharge enters the ground, the rate and direction of ground-water flow is governed mainly by gravity and geology. Lateral ground-water flow dominates in the gently-dipping Tertiary and Cretaceous strata of the Book Cliffs, where layers of low-permeability rock that impede downward movement are common. Both lateral and vertical flow may be channeled through faults and fractures, but plastic or swelling clays that can seal faults and fractures are abundant. Typically, ground-water flow continues both laterally and downward until it intercepts the surface and is discharged as a spring or seep, enters a stream as baseflow, is transpired by vegetation, or simply evaporates. Ground water tends to flow more readily through shallower systems because the hydraulic conductivities are generally larger than those of deeper systems, but some of the ground water will flow along deeper, slower flow-paths.

Generally, springs are associated with contacts between zones or strata of differing permeability or with faulting. The majority of springs in the Book Cliffs Area II CIA issue near the contact between the Flagstaff Limestone and the North Horn Formation. Water percolates down through the Flagstaff, but the clay, shale, and siltstone layers of the North Horn impede further downward movement, creating a perched system in the Flagstaff.

Springs, or areas of multiple springs, are, or have been, monitored within the Book Cliffs Area II CIA by Canyon Fuel Company and its predecessors. A number of springs were also identified in SUNEDCO's Sage Point/Dugout Canyon MRP, in the original Soldier Canyon Mine permit application, by Waddell and others (1986), on USGS topographic quadrangles, in a 1993-1994 survey by EIS (sub-Appendix C of Appendix 7-3, Dugout PAP), and by Seiler and Baskin (1988). (The EIS survey was patterned after a 1981 survey by PG&E but the PG&E survey itself was not available.) Plate 1 shows locations for springs, streams and surface water monitoring sites, boreholes, and ground-water monitoring wells. Plate 2 provides identification of the springs and surface monitoring sites and Plate 3 identifies boreholes and wells. There are multiple names for many of the springs; Table 3 gives locations of identified springs and correlates different names that have been used. Additional information may require revision of Table 3.

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[illegible]

HYDROLOGIC SYSTEM

FORMATION (possible alternative)	ELEV	LOCATION				NAME OR NUMBER								NOTES and COMMENTS
		Latitude and Longitude		Township and Range		Canyon Fuel Company CANYON FUEL COMPANY (1997)		SUNEDCO Sage Point/ Dugout Canyon MRP	Soldier Canyon MRP	USGS	EIS (1993; PG&E 1981)	Name (Most from Sage Point/ Dugout Canyon MRP)	Vaughn Hansen Assoc (1980)	
						Sldr Cyn	Dug=t Cyn							
(alluvium)		39°	110°	35	daa						CC-27			in canyon bottom-stream bed (EIS).
(alluvium)				35	dad						CC-28			in canyon bottom-stream bed (EIS).
	7090	44 09	37 50	36	aad	1		52						
(alluvium)				36	dbd						CC-37			in canyon bottom-stream bed (EIS).
				36	dca						CC-35			pond (EIS).
	8180			36	cdc	23					CC-36			possible bedrock spring (EIS).
				12 S	12 E									
	7560	44 22	37 13	30	dec	2	SP-2	53						
	7400	44 00	35 33	33	bec	3	SP-3	54						
	7605	43 32	34 15	34	ccd	4	SP-4	3						
				13 S	11 E									
	8064*			1	cca					*ACS1	CC-38			approx. 15 ft above stream bed (EIS); *Seiler and Baskin (1988).
(North Horn, alluvium)				1	ccd						CC-39			in canyon bottom-stream bed (EIS).
	7930	43 28	37 43	1	dab	5***		55	*S31-1	topo quad	CC-53		*S31-1	*shown in Sec 31, T12S, R12E; possible bedrock spring (EIS); ***two sites have been monitored as 5 by SOLDIER CREEK COAL COMPANY.
	7940*			1	dab					*ACS2	CC-54			pond (EIS); *Seiler and Baskin (1988).
(North Horn)				1	dda	5***					CC-55			pond - labeled Spring 5 on EIS map; ***two sites have been monitored as 5 by SOLDIER CREEK COAL COMPANY; this is the current site, apparently pipe flow into pond.
(North Horn)	8040			12	bba	24					CC-40			possible bedrock spring (EIS).
				13 S	12 E									
	7480	43 27	2934	4	acd	7	SP-7	57		*G-87				*Waddell and others (1986).
	7910	43 03	34 46	4	cdl	9	SP-9	33						
	7900	42 30	35 18	8	daa	15	SP-15	39		*G-90		Lower Little Pine		*Waddell and others (1986) - location of G-90 is unclear, may be either Spring 15 or 17.

HYDROLOGIC SYSTEM

FORMATION (possible alternative)	ELEV	LOCATION				NAME OR NUMBER								NOTES and COMMENTS
		Latitude and Longitude		Township and Range		Canyon Fuel Company CANYON FUEL COMPANY (1997)		SUNEDCO Sage Point/ Dugout Canyon MRP	Soldier Canyon MRP	USGS	EIS (1993; PG&E 1981)	Name (Most from Sage Point/ Dugout Canyon MRP)	Vaughn Hansen Assoc (1980)	
						Sldr Cyn	Dug=t Cyn							
	7940	42 31	35 25	9	cbb	17	SP-17	40	S8-1	*G-90; **topo quad;		Upper Little Pine	S8-1	*Waddell and others (1986). - location of G-90 is unclear, may be either Spring 15 or 17. **right on section line between sec= 8 and 9.
	8090*	42 11	43 39	9	dec s1	18	SP-18	31		*G-91				*Waddell and others (1986) shows elevation as 8120.
	8090	42 12	34 18	9	ddc	20	SP-20	30		*G-92				*Waddell and others (1986).
	7740	42 55	33 26	10	abb	21	SP-21	4		*G-93		Water Hole		*Waddell and others (1986).
(alluvium)	7895	42 50	33 08	10	ada s1		SC-41	41						
	7870	42 42	33 11	10	adb s1	22	SP-22	42		*G-94		Pine Canyon		*Waddell and others (1986), includes stream seepage.
	7845	42 43	33 13	10	adb s2		SC-41A	41A						
	7990	42 34	32 16	11	acd		G-95	44		*G-95		Y Spring		*Waddell and others (1986), includes stream seepage.
				11	bba s2		SC-105							
(alluvium)	7980	42 42	32 56	11	bcb		SC-11	11						
(alluvium)	8070	42 45	32 42	11	cdb		SC-58	58						
(North Horn)				11	cha		SC-104							At contact with Flagstaff.
	7870	42 24	31 28	12	cad		SC-59	59						
	7940	42 28	31 48	12	cbb		G-97	49		*G-97				*Waddell and others (1986).
	8000*	42 32	31 17	12	dbb		G-96	51		*G-96				*Waddell and others (1986), Table 5 shows G-96 at 8360" elev. in Colton Fm., corresponding with 50, but Plate 1 shows G-96 at same location as 51 in Flagstaff at approx. 8000' elev.
				13	aaa s1		SC-115							
				13	aaa s2		SC-114							
	7920	41 58	30 49	13	aad		SC-83	60		*G-98				*Waddell and others (1986)
				15	b					*G-98.1				*Waddell and others (1986); same area as SC-12, SC-13, and SC-14.
(Alluvium; at contact with North Horn)	8180	41 59	33 46	15	bac s1		SC-13	13						
(North horn)	8235	41 59	33 37	15	bad		SC-12	12						
				13 S	13 E									
				18	bbb		SC-84							
				18	bbc		SC-82							in canyon bottom-stream bed (DCMRP Plate 7-1).
				18	bbd s1		SC-85							in canyon bottom-stream bed (DCMRP Plate 7-1).

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FORMATION (possible alternative)	ELEV	LOCATION				NAME OR NUMBER										NOTES and COMMENTS
		Latitude and Longitude		Township and Range	Canyon Fuel Company CANYON FUEL COMPANY (1997)		SUNEDCO Sage Point/ Dugout Canyon MRP	Soldier Canyon MRP	USGS	EIS (1993; PG&E 1981)	Name (Most from Sage Point/ Dugout Canyon MRP)	Vaughn Hansen Assoc (1980)				
					Sldr Cyn	Dug=t Cyn										
		39°	110°													
				18	bhd s2		SC-86									
(North Horn - at contact)				18	cab		SC-113									
(Colton - close to contact)				20	aaa s3		SC-112								in canyon bottom-stream bed (DCMRP Plate 7-1).	
				20	aaa s4		SC-109								in canyon bottom-stream bed (DCMRP Plate 7-1).	
				20	aaa s5		258									
(North Horn; at North horn - Flagstaff contact)				20	adb		SC-108									
NORTH HORN																
				13 S	11 E											
(North Horn - Price River contact)	7600			12	bcc					*ACS9					*Seiler and Baskin (1988).	
				13 S	12 E											
(Flagstaff; at Flagstaff - North Horn contact)	7410	43 29	34 54	4	bdc	8	SP-8	2		*G-88 (Tf)					*Waddell and others (1986).	
	6980	43 14	36 17	5	cbc s1	10	SP-10	8		*G-89		Sulfur			*Waddell and others (1986).	
	6980*	43 16	36 16	5	cbc s2	11	SP-11	24		*ACS12					*Seiler and Baskin (1988), elevation listed as 6930.	
	6970	43 09	36 20	5	ccb	12	SP-12	9								
(Castlegate)	7160			7	aba					*ACS13					*Seiler and Baskin (1988).	
(Price River)	7600			7	chb	14			S7-1					S7-1		
	6880	42 50	36 23	7	aad		SP-13	10								
	7840	42 26	35 18	8	dad	16	SP-16	38				Timber Road				
	8090	42 09	34 37	9	dcc s2	19	SP-19	32								
(Flagstaff - at contact)				12	cda s1		SC-100									
(Flagstaff - at contact)				12	cda s2		SC-101									
				13	edh		SC-87									
				14	bdb		SC-102									
	8150	41 57	33 49	15	bac s2		SC-14	14				Buck Spring				

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FORMATION (possible alternative)	ELEV	LOCATION				NAME OR NUMBER								NOTES and COMMENTS
		Latitude and Longitude		Township and Range	Canyon Fuel Company CANYON FUEL COMPANY (1997)		SUNEDCO Sage Point/ Dugout Canyon MRP	Soldier Canyon MRP	USGS	EIS (1993; PG&E 1981)	Name (Most from Sage Point/ Dugout Canyon MRP)	Vaughn Hansen Assoc (1980)		
					Sldr Cyn	Dug=t Cyn								
	8075	41 51	33 56	15	bca s1		SC-15	15						
	8050	41 49	34 00	15	bca s2		SC-16	16						
(Alluvium; at North Horn - Price River contact)	7800	41 42	34 22	16	adc		SC-17	17						
	7940	41 45	34 11	16	add		SC-18	18						
				13 S	13 E									
				17	ccc s1		SC-93							
				17	ccc s2		SC-95							
				17	ccd		SC-94							
(*Colton; Flagstaff; near Colton - Flagstaff contact; this spring is also listed under Colton.)	8200	41 58	30 23	18	bac		SC-65	65						*Dugout Ck. Plate 6-1 and 7-1 indicate Colton; Sage Ck. Table IV- B.11 indicates North Horn.
				18	cbd		SC-88							
(Flagstaff; at Flagstaff - North Horn contact)				18	dca		SC-89							
				19	aaa s1		SC-106							
				19	aaa s2		SC-116							
				19	aaa s3		SC-91							in canyon bottom-stream bed (DCMRP Plate 7-1).
				19	acc		92A							
				19	aad s1		SC-90							
				19	aad s2		SC-92							
				19	acc		228							
				19	ada		SC-117							in canyon bottom-stream bed (DCMRP Plate 7-1).
				20	aac s1		SC-107							in canyon bottom-stream bed (DCMRP Plate 7-1).
				20	aac s2		259							
				20	aca		SC-96							in canyon bottom-stream bed (DCMRP Plate 7-1).
				20	dac		SC-97							in canyon bottom-stream bed (DCMRP Plate 7-1).
				20	dad		SC-98							in canyon bottom-stream bed (DCMRP Plate 7-1).
	7940	40 32	28 17	21	cca s1		203	66				Pace Canyon		
				21	cca s2		204							

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FORMATION (possible alternative)	ELEV	LOCATION		NAME OR NUMBER										NOTES and COMMENTS
		Latitude and Longitude		Township and Range	Canyon Fuel Company CANYON FUEL COMPANY (1997)		SUNEDCO Sage Point/ Dugout Canyon MRP	Soldier Canyon MRP	USGS	EIS (1993; PG&E 1981)	Name (Most from Sage Point/ Dugout Canyon MRP)	Vaughn Hansen Assoc (1980)		
					Sldr Cyn	Dug=t Cyn								
		39°	110°	13 S	11 E									
(Price River, alluvium)				3	dbb						CC-52			in canyon bottom-stream bed (EIS).
	7040			10	aaa					*ACS4				in canyon bottom-stream bed; *Seiler and Baskin (1988).
	7240			10	acb*					*ACS7				*Seiler and Baskin (1988), could be Aacc@.
(alluvium)				11	bbb						CC-5			in canyon bottom-stream bed (EIS).
				13 S	12 E									
				23	aad		SC-80							in canyon bottom-stream bed.
(Blackhawk: at Blackhawk - Castlegate contact)				23	ada		SC-81							
				13 S	13 E									
				33	aad		252							
BLACKHAWK														
				13 S	11 E									
(alluvium)	6640*			10	bac					*ACS5	CC-3			in canyon bottom-stream bed (EIS); *Seiler and Baskin (1988).
	6600			10	bac					*ACS6				*Seiler and Baskin (1988).
(alluvium)				10	bad						CC-4			in canyon bottom-stream bed (EIS).
				10	d									25-1 in Centennial Project MRP.
	7000			11	cbd					*ACS8				*Seiler and Baskin (1988).
(Aberdeen)	6720	41 47	38 01	13	acc	6		56			CC-61	Drink		"not located" (EIS).
	6800			13	bdd					*ACS10				*Seiler and Baskin (1988).
(alluvium)				13	caa						CC-60			in canyon bottom-stream bed (EIS).
(alluvium)				13	dbc						CC-59			"no flow" (EIS).
(alluvium)				13	dca						CC-58			in canyon bottom-stream bed (EIS).
(alluvium)				14	bbe						CC-15			in canyon bottom-stream bed (EIS).

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Beginning in 1991, MW-1C, MW-1M, MW-2M, and MW-3M (Plate 2) were used to monitor water quality at the waste rock disposal site previously proposed for the Soldier Canyon Mine, but monitoring of these four wells was discontinued in 1997 when the proposed waste rock disposal site was removed from the Soldier Canyon Mine MRP. Three wells were completed in the Mancos Shale: MW-1M was drilled 50 feet into competent bedrock and MW-2M and MW-3M were drilled to elevations to match the elevation of MW-1M. These three bedrock wells were dry when initially measured soon after completion but subsequent water level measurements indicated a gradient of 0.021 to the north-northeast. This gradient, which is opposite to the apparent regional gradient in the Mancos, has been interpreted as indicating a mound of water that has been formed by seepage from nearby Anderson Reservoir into the Mancos. Water quality data support this concept: there were two samples from each well, and TDS concentrations were between 6,000 mg/L and 13,000 mg/L.

MW-1C was completed at the contact between surficial colluvium and Mancos Shale bedrock. Water in the colluvium is perched on unsaturated shale and originates from the surface water system: TDS was over 13,000 mg/L in the three samples from this well.

The Division approved a waste-rock disposal site for the Dugout Canyon Mine on March 3, 2003. The Permittee monitors five sites near the waste-rock site, they sites are: SS-1, SS-2, DH-1, DH-2, and DH-3. SS-1 and SS-2 are both surface sites and have been monitored frequently since May of 1998. Both sites are in ephemeral drainages, and the Permittee has observed no flow in either drainage. Sites DH-1, DH-2, and DH-3 are water-monitoring boreholes near the waste-rock site. The Permittee measures each for water depth/elevation, and monitored DH-1 for quality each quarter from 2003 to 2004. They currently monitor DH-1 for quality once a year.

In August 1986, boreholes SC-11G, SC-12G, and SC-13G were drilled from the Rock Canyon Seam workings of the Soldier Canyon Mine; down through the Gilson Seam and a 13- to 20-foot thick, clean sandstone located approximately 40 to 50 feet below the Gilson Seam. Hydraulic conductivities of 2×10^{-7} to 10^{-6} cm/sec were measured in SC-11G and SC-13G, but hydraulic conductivity was 1.5×10^{-3} cm/sec in SC-12G. The tests measured the hydraulic conductivity of the entire stratigraphic sequence. Ground water was under confined conditions in all three boreholes, and in SC-12G the measured head was 250 feet above the floor of the mine and water flowed into the mine until the hole was capped. The gradient determined from the three boreholes was 1,800 ft/mile (approximately 12°) in a direction N 11° E. Even assuming the boreholes measured the hydraulic properties of the same stratigraphic sequence at three different locations, the range of hydraulic conductivities shows great inhomogeneity and the true potentiometric surface is almost certainly not planar with a uniform dip to the north-northeast. No further measurements have been reported for these wells and they are no longer usable as far as is known. Information on these three boreholes, including driller's logs, is in Appendix 7-I of the Soldier Canyon Mine MRP.

Boreholes SC-2, SC-8, and SC-10 and a "gas boring" were also drilled from the Rock Canyon Seam down to the Gilson Seam some time prior to the boring of SC-11G, SC-12G, and SC-13G. Water levels measured in August 1986 in these four older borings indicated a

potentiometric surface that roughly matched the strike and dip of the coal seam. It was concluded that the water in these uncased boreholes had drained from the mine floor and the water levels were not valid for determining a potentiometric surface (Appendix 7-I of the Soldier Canyon Mine MRP). Accessibility and functionality of other in-mine borings is not discussed in the Soldier Canyon MRP.

Two water supply wells, #1 and #2, were constructed in 1980 at the Centennial Project, located to the west in Deadman Canyon. The Centennial MRP provides some information on their construction and testing. Well #1 was 130 feet deep and initially had a static water level 58 feet below the surface. The level was lowered to 67 feet after four hours of pumping at 50 gpm. After three months of use, the well was almost dry and there was little recharge. Well #2 was drilled to 155 feet and static water level was at 57 feet. Two hours of pumping at 30 gpm lowered the water level to 88 feet. The well was then deepened to 280 feet, and a second test lowered the level to 100 feet after only one hour pumping at 30 gpm. After three weeks well #2 almost stopped producing water, and recharge was very slow. These results indicate that the aquifer is perched, small, and not capable of sustained yield; even though initial pump tests appeared favorable. Well #1 is monitored, but neither well is used for water supply because of excessive drawdown when pumped. [In the Mayo and Associates 14 August 1996 reports, Appendix 7-3 in the Soldier Canyon MRP and Appendix 7-M in the Dugout Canyon Mine MRP, these wells are identified as water wells #1 and #3 on page 43 and the locations in Deadman Canyon are shown on Figure 9. The pump test and water level data for well #1 in these reports match the data for Centennial's Well #1 and data for well #3 match the data for Centennial's well #2.]

Four borings were done by Soldier Canyon Mine in Soldier Canyon to determine geotechnical properties and the potential for water inflow to a proposed #3 fan shaft. All four of those borings were dry (Exhibit 7.42-1, Soldier Canyon Mine MRP).

Most water entering the Soldier Canyon Mine comes through leaks in the mine roof. Average annual flow into the mine between 1988 and 1994 was approximately 420 gpm (220,000,000 gallons per year). Sumps, pumps, piping, and free flow along the mine floor manage movement of water within the mine. Water not used in the mine or lost to evaporation is collected in an in-mine settling pond and discharged to Soldier Creek through UPDES permitted discharge point 003, also identified as MW-2 (Mayo and Associates, 1996, p. 17).

Average daily discharge rates from 1985 to May 1998, taken from monthly Discharge Monitoring Reports (DMR) for UPDES 003, varied between 30,000 gpd (21 gpm) to 967,000 gpd (672 gpm). Maximum measured flow from DMRs during that period was 1,075,000 gallons per day (750 gpm); minimum flow was not reported on the DMRs. Average annual discharge was about 170,000,000 gallons per year (285 gpm). Daily discharge rates were greatest in 1991, annual discharge greatest in 1992 (Figure 5). Data for 1988 were not available. Coal production stopped in October 1998, and from June 1998 through May 2005, (when the Division completed this CHIA) there was no water discharged from the mine. Canyon Fuel Company has attributed the variability of the discharge to changing water management practices in the Soldier Canyon Mine, and measurement errors; rather than to variations in flow into the mine. However, yearly

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coal production did increase from 1985 to 1990, with production for 1989 through 1991 roughly double what was typical for the mine during most other years. Coal production was high in 1996

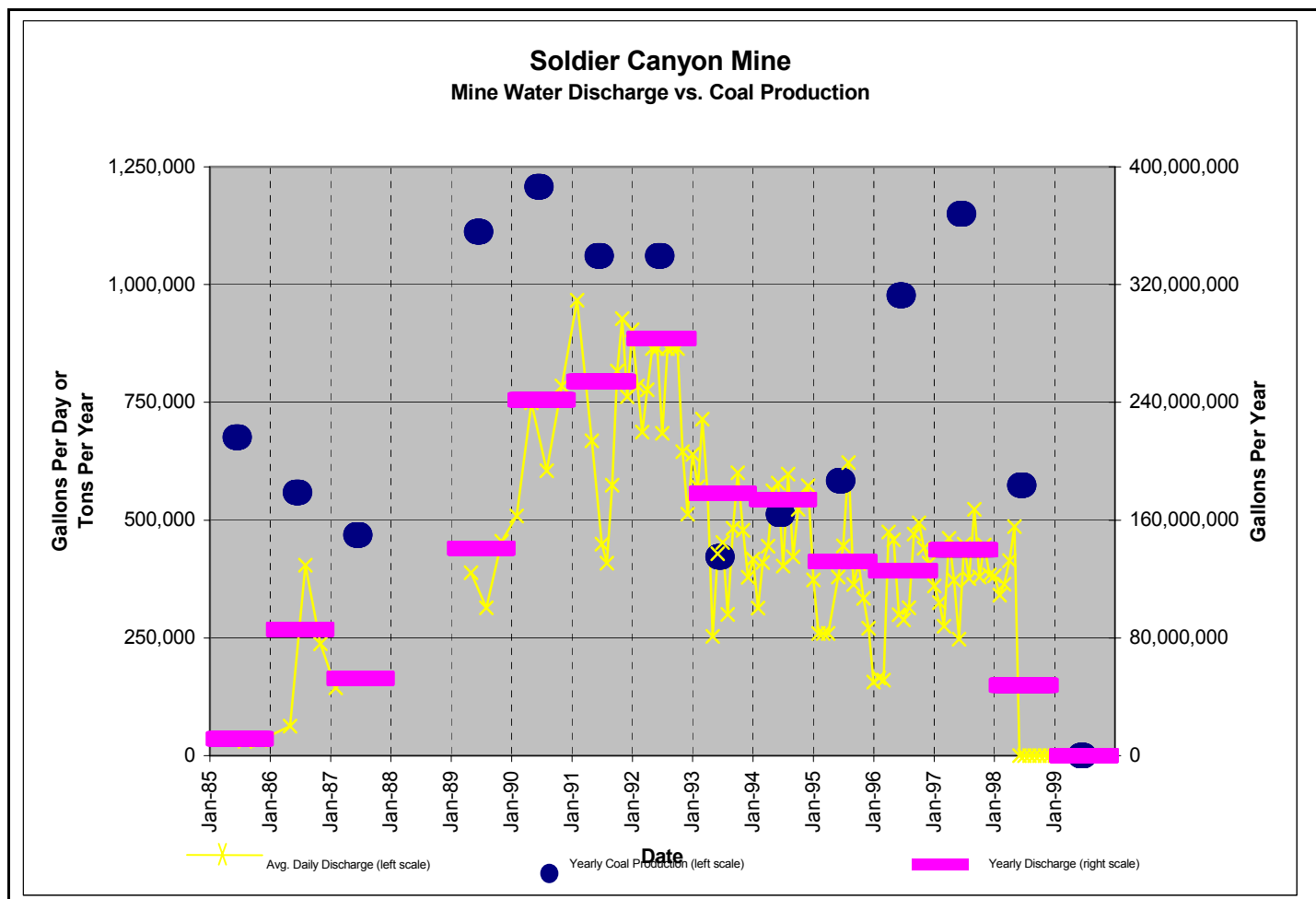


Figure 5

also, but there was no corresponding increase in water discharge (Table 1 and Figure 5). Yearly flows from annual reports generally correspond with yearly flows calculated from DMR data (Table 1).

During exploration in 1995, the old Dugout Canyon workings were found to be flooded, but water did not issue from the portals. Isotopic data indicated water in the mine was modern water. Coal production from the Dugout Canyon Mine began in 1998: there was no reported mine water discharge until 2002, when Canyon Fuel discovered a large amount of water stored in an abandoned mine adjacent to the Dugout Canyon workings (Knight-Ideal Mine). For safety reasons, the Mine Safety and Health Administration (MSHA) required Canyon Fuel to dewater the abandoned workings as quickly as possible. This resulted in discharges ranging from 1565 to 1750 gpm, with total iron concentrations from 4.5 to 5.0 mg/l. Total dissolved solids averaged 1400 mg/l, or 27,000 to 30,000 lbs/day. Since August 2002 the water discharge (water comes

from the Knight-Ideal Mine) has averaged 45 gpm with increased levels during the spring runoff.

Because the discharge at times is so high in terms of flow, the total dissolved solids limit (UPDES Permit) was regularly exceeded. Since that time, the Division of Water Quality (DWQ) has allowed a higher ton-per day limit, as long as the mg/l limit is not exceeded. Canyon Fuel is also participating in a salinity offset program, as approved by DWQ.

Canyon Fuel Company took various samples of the discharge water, and the receiving streams at several different points along the flow route to determine the impacts from the discharge. The Division concluded that the water had no adverse effects, and in fact was a benefit in light of the drought at the time.

Ground-water quality varies greatly, depending on geology, physiography, and elevation. Waddell and others (1986) indicate that TDS concentrations range from 250 to 2,000 mg/L in the Book Cliffs area. The best quality occurs in or near mountain recharge areas and the poorest quality in lowland areas. The chemical characteristics of the ground water vary vertically from formation-to-formation and laterally within each formation. TDS in water from the Flagstaff Limestone ranges from 250 to 500 mg/L, whereas TDS in the Blackhawk and North Horn Formations range from 500 to 2,000 mg/L. The principal chemical constituents in Flagstaff water are calcium and bicarbonate. Water from the Blackhawk is of variable chemical composition with no single dominant cation or anion. Where dissolved solids concentrations from water in the Blackhawk are affected by the Mancos Shale, sulfates of sodium and magnesium increase significantly. Waters from springs G99 and G99.5 that issue near the contact between the Blackhawk Formation and the Mancos Shale have specific conductances that indicate TDS concentrations of 1,600 and 2,000 mg/L, respectively (Mundorff, 1972; Waddell and others, 1986).

Saturation indexes indicate that most ground waters are at saturation with respect to calcite. Ground waters are generally undersaturated with respect to dolomite, gypsum, and anhydrite (Waddell and others, 1986).

Surface Water

The Book Cliffs Area II CIA is situated in the Book Cliffs near the headwaters of the Price River basin. The headwater area of Cow Canyon, which drains north to Nine Mile Creek, has been included in the CIA because small sections of federal lease U-07064-027821 and the SITLA tract cross over the drainage divide into the Nine Mile Creek drainage (Plate 1); however, no mining or mining related impacts, such as subsidence, are anticipated in this drainage.

The Price River meets the Green River about 40 miles southeast of the mines (Figure 2). The Green River flows southward from its confluence with the Price River approximately 75 miles until it discharges into the Colorado River (Figure 1).

Flow in the Price River is regulated at Scofield Reservoir. Discharge is measured at several locations both upstream and downstream of the confluences with Coal, Soldier, and

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Grassy Trail Creeks, the streams that drain the CIA (Figure 2). The area of the Price River drainage is 455 square miles above USGS gauging station 09313000 near Helper, approximately 17 miles upstream of Coal Creek, and 1,540 square miles above USGS gauging station 09314500 near Woodside, about 24 miles below the confluence with Soldier Creek. Water is taken from the river and its tributaries for irrigation between these two stations.

As of May 2005, USGS water discharge data are available for station 09313000 for water years 1934 to 1969, 1979 to 1981, and 1990 to 2003.¹ Extreme flows recorded were 9,340 cfs (4.2 million gpm) on September 13, 1940 and 0.9 cfs (404 gpm) on August 21, 1961. The mean annual flow volume for the three periods of record is 108 cfs (48,511 gpm, or 78,255 acre-feet/year).

USGS water discharge data are available for station 09314500 for water years 1909 to 1911 and 1945 to 1992, and 2000 to 2004.¹ Maximum recorded discharge was 11,200 cfs (5 million gpm) on September 7, 1991. Periods of no flow were recorded in 1960, 1961, 1992, 2002, 2003, and 2004. The mean annual flow volume (1946 to 2003) was 116 cfs (52,057 gpm, or 83,974 acre-feet/year). Limited water quality data are available for 1946 to 1949, 1951 to 1997, and 2002 (Table 4).

Discharge of the Green River has been measured at USGS gauging station 09315000 at Green River, Utah, about 12 miles below the confluence of the Price and Green Rivers (Figure 2). For water years 1894 to 1899 and 1904 to 2004 flow ranged from a minimum of 510 cfs (228,888 gpm) on December 1, 1919 to a maximum of 68,100 cfs (30 million gpm) on June 27, 1917. Average annual discharge is 6,192 cfs (2.8 million gpm, or 4,484,000 acre-feet/year)¹. Water quality data are available for 1928 to 2004 (Table 4).

Snowmelt is the major source of water for the perennial streams of the Price River basin. Intense summer thunderstorms may cause short-term flooding but not large volumes of runoff. Intermittent and ephemeral streams are abundant, existing primarily at lower elevations where potential evapotranspiration exceeds precipitation. Many streams that originate in the Book Cliffs are perennial at higher altitudes but become ephemeral as they emerge from the mountains and flow onto the lowlands (Waddell and others, 1981, p. 7).

Water use in the higher elevations of the Price River basin is primarily for wildlife and stock watering purposes. The upper watershed provides most of the domestic water needs for the lower valley. Within the lower valley area, agricultural activities utilize some of the water (Mundorff, 1972). Minimum flows in the gauged streams and rivers in the basin occasionally reach zero. Storage reservoirs are common at higher elevations.

¹ U.S. Geological Survey, 2001, National Water Information System (NWISWeb) data available on the World Wide Web, accessed May 26, 2005, at URL <http://waterdata.usgs.gov/nwis/>.

Sediment yields from the upper portion of the Price River basin are small, with erosion rates varying from 0.1 to 0.5 ac-ft/mile²/yr. Lowest rates are from the higher parts of the Book Cliffs, where exposed rocks are dominantly limestone and dolomite. The bulk of the sediment in the Price River comes from the more erodible sandstones and shales that are common at lower elevations, where annual sediment yields of 0.5 to 3.0 ac-ft/mile²/yr are reported by Waddell and others (1981, Plate 6).

In general the quality of water in the headwaters of the Price River basin is excellent. Waddell and others (1981) report that the Price River and its tributaries generally have a TDS concentration of between 250 to 500 mg/L upstream from Helper, and the water type in this area is calcium bicarbonate. However, the quality of water in the Price River rapidly deteriorates down gradient. Below the town of Helper, most flows originate on Mancos Shale or are irrigation return flows from lands situated on Mancos-derived soils (Price and Waddell, 1973). The Price River near the confluence with Soldier Creek has an average TDS content of about 1,700 mg/L, including sulfates of calcium, magnesium, and sodium. At USGS station 09314500, the weighted average TDS content is between 2,000 and 4,000 mg/L, with the water type being strongly sodium sulfate (Mundorff, 1972).

Surface Water Hydrology of the CIA

The Book Cliffs Area II CIA covers approximately 62,630 acres (98 mi²) of the Coal, Soldier, Dugout, Pace, Rock, and Cow Canyon watersheds (Figure 3). Topography in the area is rugged, with elevations varying from 6,600 ft to approximately 8,300 feet above sea level. Slopes vary from vertical cliffs, to less than 2% along the ridges, to nearly flat on the valley floor.

Water resources within or adjacent to the Book Cliffs Area II CIA include a few low yielding springs and streams. There are no major water bodies located within or adjacent to the CIA.

Most surface water in the CIA drains to the Price River by way of Coal and Soldier Creeks, perennial tributaries to the Price River, and numerous intermittent streams. Perennial flow from a small area at the head of Cow Canyon drains north to Nine Mile Creek (Figure 3, Plate 1), another tributary to the Green River.

Soil cover varies with slope, with bare sandstone cliffs along the upper portions of the canyons, shallow silty soils on the milder slopes, and shallow sand-gravel alluvium in the channel bottoms. The soils classify as hydrologic soils group C and D. The infiltration rates of these soils result in moderately low infiltration capacity.

The approximate average annual sediment yield is 0.1 to 1.0 ac-ft/mile²/yr across the CIA, but most of the area falls in the range of 0.5 to 1.0 ac-ft/mile²/yr (Waddell and others, 1981, Plate 6). Thus, the average annual sediment yield of the Book Cliffs Area II CIA is estimated to be 49 to 98 ac-ft/yr for undisturbed conditions.

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Coal Creek

The headwater area of Coal Creek is near the crest of the Book Cliffs (Plate 1 and Figure 3) on rocks of the Green River and Wasatch Formations, at an altitude of approximately 9,000 feet. The stream cuts a steep, deep, narrow channel through Cretaceous strata to the base of the Book Cliffs, and from there meanders across a gently sloping plain on the Mancos Shale to its confluence with the Price River. USGS monitoring station 09313965 (Plate 2) is located on Starpoint Sandstone at an elevation of 6,370 feet, approximately 0.9 miles below the closed Knight Ideal Mine. The drainage area above station 09313965 is 25.3 square miles, at an average altitude of 7,700 feet. The stream is 8.8 miles long with a slope of 152 feet per mile (Waddell and others, 1986).

The USGS measured discharge of Coal Creek seasonally, May to November, for water years 1979 to 1981 at station 09313965. As is typical of the region, most recorded flow was from snowmelt at higher elevations, and in Coal Creek maximum daily mean discharges were 30 cfs to 80 cfs (13,000 gpm to 36,000 gpm) between late May and early June; however, the highest daily mean discharge was 120 cfs (54,000 gpm) on September 10, 1980 and the minimum daily mean was 0.02 cfs (9 gpm) on August 6 through 9, 1981 (USGS, 1981 and 1982). The extreme maximum flow measured was 458 cfs (200,000 gpm) on August 13, 1979, the result of a thunderstorm, and no flow was observed for part of at least one day (Price and Plantz, 1987).

Baseflow measurements (Price and Plantz, 1987) indicate that in the reach above the Knight Ideal Mine, the creek gains baseflow from the Blackhawk Formation at all flow stages. Below the mine, in the lower Blackhawk Formation and Starpoint Sandstone, the measurements indicate the creek gains flow at high stages and loses flow at low stages.

Water quality was measured in 22 samples from station 09313965 from 1979 to 1981. TDS ranged from 480 to 810 mg/L, with a mean value of 605 mg/L. Dominant cations were magnesium and sodium and dominant anions were bicarbonate and sulfate (Price and Plantz, 1987). Only three samples were analyzed for mercury, but mercury concentrations ranged from below-detection-limits up to 5 µg/L, the latter exceeding Utah Division of Water Quality criteria for domestic water sources (2 µg/L, Class 1C) and aquatic wildlife (2.4 µg/L, Classes 3A-3D).

Phenol concentrations, determined from nine samples, were from below-detection-limits to 35 µg/L (Price and Plantz, 1987). Phenols come from natural organic sources but can also be indicators of polluting effluents from industrial processes, including coal mining. The limit for Class 1C waters is 300 µg/L (UDWQ, 1994). The Utah water quality standard for phenol for aquatic wildlife (Classes 3A-3D) is 10 µg/L, but for many species of fish 5 µg/L has been reported to be harmful (Waddell and others, 1981).

Total Suspended Solids (TSS) in thirteen samples ranged from 3 to 2,710 mg/L. Calculated instantaneous sediment loads for the three water years ranged from less than 0.01 tons/day to 302 tons/day. Coal was only 0.4% of stream-bottom sediment (Price and Plantz, 1987).

Price and Plantz (1987) reported a healthy stream-bottom environment was indicated by benthic-invertebrate diversity. Phytoplankton had a fairly uniform distribution of green algae, probably reflecting the fairly good chemical quality of the water.

Soldier Creek

The headwaters of Soldier Creek are located in the Roan Cliffs and Whitmore Park as shown on Plate 1 and Figure 3. The creek flows for 13.5 miles generally southward to the Anderson Reservoir diversion. Anderson Reservoir stores water for irrigated fields. Soldier Creek discharges into the Price River about 10 miles south of the reservoir diversion. The lower 19 miles of Soldier Creek flows over Mancos Shale.

Soldier Creek is intermittent above G-1 (Plate 2), with springs contributing small quantities of water that maintain portions of the stream before the water is consumed by evaporation and infiltration. The stream is perennial between sampling location G-1 and the Anderson Reservoir diversion. Soldier Creek would be perennial in the reach between the diversion and the confluence with the Price River but irrigation often consumes the entire flow during the low-flow period.

Station G-1 monitored flow from an area of 5.4 square miles with an average altitude of 7,900 feet. The average stream gradient is 10% and the average gradient of the land surface is about 30%. From 1987 through 1998, Canyon Fuel Company monitored Soldier Creek at station G-1 from one to four times per year. Reported instantaneous flow varied from 760 gpm to 40 gpm; however, water was analyzed for quality some quarters when no flow volume was reported, possibly because ice and snow precluded accurate flow measurement. TDS ranged from 136 to 656 mg/L (Appendix 7-7 Dugout Canyon Mine MRP, Division Database).

In 1997 The Division approved station G-6 to replace station G-1 for monitoring Soldier Creek upstream of the Soldier Canyon Mine disturbed area. G-6 is much closer to the disturbed area and will provide a more accurate basis for determining the impacts of mine operations on Soldier Creek. G-1 and G-6 were monitored concurrently for two years before G-1 was abandoned in 1999. G-6 is also near the contact of the Blackhawk Formation and Castlegate Sandstone and will be used as part of a baseflow study when conditions, as given in the Soldier Canyon Mine MRP, are favorable. From August 1997 to October 2004, reported instantaneous flow varied from 0.39 to 9375 gpm, with an average of 528 gpm. TDS ranged from 200 to 640 mg/L, with an average of 434 mg/L.

Although the exact location of sampling location G-4 on Soldier Creek is no longer known, it was just below the confluence with Pine Creek. (G-7, shown on Plate 2, is at or near the location of G-4 and is considered the equivalent of G-4. Some water-quality analysis was done for G-7 in 1997, but G-7 is mainly for collection of stream gain-loss hydrograph data during "wet" and "dry" years, which are defined in the Soldier Canyon Mine MRP. Water quality data will be collected in conjunction with the gain-loss data collection.) The watershed upstream of G-4 has a total area of approximately 15 square miles. Water quality of Soldier Creek at G-4 is similar to that of Pine Creek. TDS concentrations in 54 samples, collected 1976

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through 1986, varied from 220 mg/L to 860 mg/L and averaged 455 mg/L ($\sigma_{n-1} = 111$). The dominant constituents were calcium and bicarbonates. The pH varied from 7.6 to 9.84 (67 samples). Average pH was 8.3 ($\sigma_{n-1} = 0.4$). Suspended solids concentrations as high as 12,000 mg/L were measured during the February to May snowmelt, but typical levels were less than 70 mg/L (Appendix A of Appendix 7M, Soldier Canyon Mine MRP).

Sampling point G-5 is located on Soldier Creek just downstream from the Soldier Canyon Mine (Plate 2). The station is the same as USGS stream gauging station 09313975. The altitude of the gauge is 6,650 feet. Area of the drainage basin above the gauging station is 17.7 square miles, and average elevation of the basin is 7,599 feet. The stream channel is 5.9 miles long and 10 to 20 ft wide near the gauging station. The creek bottom is on rocky alluvium and occasional outcrops of bedrock. The average stream channel gradient is 6%, and the average gradient of the land surface is 30%. For the entire basin, average stream and land gradients are 4% and 23%, respectively (Soldier Canyon Mine MRP, p. 7-47).

The period of record for data from USGS station 09313975 is from September 1978 to September 1984, but measurements were seasonal, with no measurements from December to February. Measured extreme flows were 472 cfs (211,800 gpm) on September 23, 1981 and 0.08 cfs (34 gpm) on August 5, 1981 (Table 4, Price and Plantz, 1987). Maximum and minimum daily mean discharges were 88 cfs (39,500 gpm) in late May 1980 and 0.17 cfs (76 gpm) in early August 1981 (USGS, 1981, 1982). Instantaneous flow at G-5, measured quarterly from June 1985 to August 1999 by Soldier Creek Coal Company and its predecessors, averaged 1,605 gpm ($n = 53$, $\sigma_{n-1} = 2,270$ gpm). Maximum reported flow was 9,575 gpm. There were no-flow reports for several quarters even though water samples were collected during those quarters, possibly because ice and snow precluded accurate flow measurement: minimum measured flow was 157 gpm.

Baseflow measurements by Price and Plantz (Figure 16, 1987) indicate that at high stage, Soldier Creek loses flow across the Castlegate Sandstone and upper Blackhawk Formation, but gains flow at lower stages. The middle Blackhawk Formation, above the Soldier Canyon Mine and station 09313975, gains at all stages.

Water quality has been measured at sampling location G-5 by Soldier Creek Coal Company since October 1979 (Appendix A of Appendix 7M, Soldier Canyon Mine MRP and Division database) and by the USGS from 1979 to 1984 (Price and Plantz, 1987). The USGS data do not reflect as much variability as the data obtained by Soldier Creek Coal Company.

TDS measured by the USGS (31 samples) varied from 280 to 710 mg/L and averaged 533 mg/L, but in the quarterly samples taken by Soldier Creek Coal Company up through 2004, TDS values ranged from 170 to 1,556 mg/L and averaged 619 ($\sigma_{n-1} = 226$), with the higher concentrations generally occurring during summer months when flows were low. The dominant constituent was calcium bicarbonate; however, the higher TDS samples showed increases of bicarbonates of sodium and calcium with some increase in sulfates. Sixty-five pH measurements by Soldier Canyon varied from 7.3 to 9.3, with most being between 7.8 and 8.8. Suspended solid concentrations were generally less than 60 mg/L, but went as high as 2,670 mg/L in spring and

early summer. Phenol concentrations reported by Price and Plantz (Table 10, 1987) for 15 samples from Soldier Creek ranged from below-detection-limits to 38 µg/L.

Water near the Soldier Canyon Mine is typical of the regional environment. A comparison of Soldier Creek water quality data with Table 4 indicates that the quality of Soldier Creek water near the mine is much better than the quality of Price River water.

Pine Creek

Pine Creek, a major tributary to Soldier Creek is shown as an intermittent stream on USGS topographic maps; however, the Dugout Canyon MRP (p.7-32) describes the headwater areas of Pine Canyon as appearing to be perennial, based on observations and water monitoring data.

The headwaters of Pine Creek are located in the area between the Book Cliffs and the Roan Cliffs near the northeastern part of the Book Cliffs Area II CIA (Figure 3 and Plate 1). The creek flows generally westward for approximately 4 miles and discharges into Soldier Creek. Surface-water sampling location G-3 is 120 ft upstream of this confluence with Soldier Creek. The drainage area above G-3 is 3.5 square miles, with an average altitude of 7,943 ft. The stream channel is narrow, 2 to 6 ft, for most of its length, and is on alluvium except for occasional outcrops of bedrock. The average gradient of the stream channel is 9%, and the average gradient of the land surface is 21% (Soldier Canyon Mine MRP, p. 7-48).

Pine Creek contains water throughout its length most of the time. However, during periods of unusually low precipitation, there are dry reaches between the springs that feed the stream. Such a dry period occurred in the summer of 1977 when there was no flow observed at G-3 during three visits (Soldier Canyon Mine MRP, p. 7-49).

Water quality in Pine Creek is good to excellent at G-3. Data are in Appendix 7-7 of the Dugout Canyon Mine MRP. Between 1976 and 1985, specific conductance varied from 430 to 756 mmhos/cm at 25°C, and the average value of 32 samples is 541 mmhos/cm ($\sigma_{n-1} = 84$). The water is predominantly a calcium bicarbonate type but a few samples showed high levels of sodium sulfate. TDS, based on 15 samples, was 215 to 756 mg/L, with an average of 379 mg/L. The pH in 25 samples varied from 7.9 to 8.6, averaging 8.3 ($\sigma_{n-1} = 0.2$). Typically, suspended solid levels were below 60 mg/L except during spring snowmelt, when concentrations exceeded 450 mg/L. Storm runoff has produced suspended solids concentrations above 20,000 mg/L (Soldier Canyon Mine MRP, p. 7-49).

Fish Creek

Fish Creek is a major tributary to Soldier Creek. It is shown as an intermittent stream on USGS topographic maps; however, based on observations and water monitoring data, Fish Creek is described in the Dugout MRP (p. 7-31) as perennial near the Dugout Canyon Mine.

Water quality and quantity was measured from June 1976 through October 1980 at

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PG&E=s site #21 (Plate 2). TDS was 285 to 481 mg/L, and averaged 360 mg/L ($n = 14$, $\sigma_{n-1} = 68$). Measured flow was 0 to 1,342 gpm, averaging 109 gpm ($n = 25$, $\sigma_{n-1} = 280$). pH was between 8.0 and 8.8.

Dugout Creek

Dugout Creek originates at an elevation of approximately 8,800 feet, near the crest of the Book Cliffs (Figure 3 and Plate 1). It cuts a steep, deep canyon through the Book Cliffs, similar to the other major streams in the area. From the base of the escarpment, Dugout Creek meanders across the Mancos Shale. Several miles south of the Book Cliffs Area II CIA boundary, it flows into Grassy Trail Creek, which is tributary to the Price River (Figure 2).

Dugout Creek is an intermittent drainage, although, similar to Fish Creek, it is described in the Dugout Canyon Mine MRP as perennial in the vicinity of the Dugout Mine (p. 7-32). Flow from Dugout Creek is diverted into the Pace Creek drainage for irrigation in Clark Valley (Plate 1), but farther downstream Pace Creek is itself tributary to Dugout Creek. Portals of the Dugout Canyon Mine are along Dugout Creek, and the disturbed area includes a culvert to carry the stream beneath the mine pad for approximately 2,000 feet.

USGS station 09313985 is at an elevation of 6,960 feet, where Dugout Creek flows across the Blackhawk Formation. Seasonal records were collected during water years 1980 and 1981. Most flow was from snowmelt during May and June, and maximum daily mean flows were 15 cfs to 35 cfs (6,700 gpm to 15,800 gpm) during May (Price and Plantz, 1987, Figure 17). Thunderstorms in August and September produced high-flow peaks, and the extreme recorded high-flow was 127 cfs (57,000 gpm) from a thunderstorm on September 5, 1981. No flow was observed for part of at least one day (Price and Plantz, 1987, Table 4). Canyon Fuel Company personnel have described the stream as perennial above the Dugout Canyon minesite but intermittent through the minesite.

PG&E monitored Dugout Creek quarterly between June 1976 and October 1980 at DC-1 below the old minesites and at DC-2 and DC-3 above (DC-3 was monitored only once during that period). In 1997 Canyon Fuel Company resumed quarterly monitoring at these three sites, and began limited monitoring at DC-4 and DC-5 farther up the canyon (Plate 2). During the periods monitored since 1976, instantaneous measured flow has averaged 640 gpm at DC-1, with the observed high of 9,100 gpm occurring in 1980. The extreme measured low of 0.04 gpm was in 2000, but there are no reports of no-flow. The data from PG&E and the USGS overlap on only one date, October 24, 1979, and the USGS daily mean (116 gpm or .26 cfs) is almost double the PG&E instantaneous flow measurement (63 gpm).

Water quality appears to be slightly better in Dugout Creek than in Soldier and Coal Creeks. TDS in 15 samples collected by the USGS (Price and Plantz, 1987) during water years 1980 and 1981 ranged from 350 to 480 mg/L, with a mean of 396 mg/L. The dominant cations were calcium and magnesium and the dominant anion was bicarbonate. No constituent was found to exceed Utah water quality standards. The maximum phenol concentration was 10 $\mu\text{g/L}$, which just matches the Utah water quality standard for aquatic wildlife of 10 $\mu\text{g/L}$. Average TDS

in the PG&E and Canyon Fuel Company samples was 420 mg/L, with extremes of 880 mg/L and 300 mg/L.

TSS in the USGS samples ranged from 5 mg/L to 1,000 mg/L, correlating with periods of low and high flow, respectively. Instantaneous suspended-sediment loads ranged from less than 0.01 to 38 tons/day. Benthic invertebrae showed good diversity based on two samples collected in water year 1980, and green algae showed fairly uniform distribution based on five samples of phytoplankton collected in water year 1981 (Price and Plantz, 1987). Canyon Fuel Company and PG&E measured TSS as high as 3,290 mg/L and as low as 1 mg/L.

Pace Creek

Pace Creek is similar to Dugout Creek, originating in the Book Cliffs at an elevation of approximately 8,800 feet and cutting a steep, deep canyon through the Book Cliffs. Flow from Dugout Creek is diverted into Pace Creek for irrigation in Clark Valley, but farther downstream Pace Creek is itself tributary to Dugout Creek, which is in turn tributary to Grassy Trail Creek, an intermittent tributary of the Price River (Plate 1).

Pace Creek was monitored in 1978 and 1979 at two locations for the Sage Point-Dugout Canyon Mine: site PC2 is at the base of the Book Cliffs just downstream of the Pace Canyon Mine, which was last active in 1940, and site PC1 is located upstream, in the Book Cliffs, at the boundary between two sub-drainages. Flow at PC-1 was sometimes greater than at PC-2.

Flow, pH, temperature, and conductivity were measured during 1979 at site 70, which is several miles below PC-2 and just above where the irrigation diversion from Dugout Creek flows into Pace Creek. Flows at site 70 were usually lower than at PC-2, and specific conductivity increased from 550 mmhos/cm to 800 mmhos/cm at PC-2 to 700 mmhos/cm to 1,800 mmhos/cm at site 70. The downstream decrease in flow and increase in specific conductivity probably are the results of evapotranspiration and flow across Mancos Shale derived soils, but also may reflect use and return flow of irrigation water. In 1979, at site 69, field parameters were measured for the water diverted from Dugout Creek: specific conductivity was between 700 mmhos/cm to 1,300 mmhos/cm. The locations of sites 69 and 70 are shown on Plate 2.

PC-1 and PC-2 were monitored in 1978 and 1979. The Permittee resumed quarterly sampling at PC-2 in 2000. At PC-2, TDS has ranged from 290 mg/L to 840 mg/L, with an average of 593 mg/L. Specific conductivity averaged 789 μ mhos/cm with extremes of 468 and 1,298 μ mhos/cm. The Permittee established monitoring site PC-1a in 1999 to replace PC-1. They collected baseline parameters (addition of the SITLA Lease) at PC-1a and PC-2 from 1999 through 2002, after which monitoring switched to operational parameters.

Canyon Fuel Company added a fan portal and related facilities adjacent to Pace Creek. The main channel is not obstructed nor lined with a culvert. Three culverts, PCUC-1, PCUC-2, and PCUC-3, direct undisturbed runoff around or under the fan portal pad. Culvert PCDC-1 directs decanted flows and overflows from the catch basin to the stream channel. Another culvert directs mine water (UPDES) flows to the creek. The Permittee has labeled the culverts

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on Plate PC7-5.

The Permittee has installed a culvert (PCUC-2) in the undisturbed channel (PCRD-1) and an undisturbed drainage ditch (PCD-2) to transmit treated runoff from the topsoil stock pile to the sediment trap. Culvert PCUC-2 is a 24 inch CMP that extends below the topsoil stock pile, under the pad where it drops into channel PCRD-1, just above the main stream channel. PCRD-1 is designed for a peak flow of 19.05 cfs resulting from the 10 yr-24 hr precipitation event. Calculated peak discharge from watershed PCWS is 5.96 cfs. The Permittee has calculated a 21 inch culvert could handle the peak flow, however they committed to use a 24 inch CMP to add extra capacity. Velocity of the peak discharge is calculated at 9.15 ft/sec, which will require 12 inch (d-50) to prevent dislodging of riprap apron. A debris structure was built above the inlet to prevent clogging of the culvert.

Runoff from the south topsoil stockpile is collected by a berm that encompasses the pile. The south end of the berm has a silt fence to filter the runoff before it flows into ditch PCD-2, then to the sedimentation trap. Ditch designs for PCD-2 are provided in Table 7-3. A peak flow of 0.06 cfs will be generated from the topsoil stockpile. The channel is designed to transport the flow from a 10 yr- 24 hr precipitation event on the topsoil stockpile.

Plate PC7-5 shows a berm that runs the length of the disturbed area above the canyon road. It should prevent disturbed area runoff from running onto the road or leaving the disturbed area. A berm circles the topsoil pile and contains its runoff. Any flow from fan portal area will be collected by the berm, then directed to catch basin.

Riprap calculations have been submitted along with a cross-section for PCUD-2 showing a filter and graded riprap to a depth of 1 foot. Plates PC5-2, PC7-4, and PC7-5 show the locations where riprap will be placed.

Plate 5-2 shows the location of three water bars on the dirt road bisecting the fan portal site. The water bars will divert water off the road. There will be a minimum amount of traffic on the road. It is used occasionally by ranchers and some mine personnel accessing the upper elevations for degasification well work. The low traffic frequency will result in minimal disturbance and less erosion of the road surface. One water bar will be placed above the site and will divert undisturbed runoff coming down the road into Pace Creek. Two other water bars will be placed at about 200' intervals below the upper water bar. The runoff generated on the road could be diverted to the silt fences.

Rock Creek

There is little information on water quality for the ephemeral acting stream in Rock Canyon. Canyon Fuel Company began three years of baseline monitoring in 1999, but of the 24 times the Permittee has monitored there, the stream was observed to be dry 19 times. The observed flows were recorded in 2000 (1), 2001 (2), 2002 (1), and 2004 (1). The highest reported flow was 55 gpm, recorded on August 17, 2004. The TDS has ranged from 240 to 1160 mg/L, with an average of 769 mg/L.

This creek should not be affected by mining, since it lies entirely outside of the subsidence zone for the Dugout Canyon Mine.

SUMMARY OF SELECT WATER QUALITY DATA FROM USGS STATIONS PRICE RIVER AT WOODSIDE AND GREEN RIVER AT GREEN RIVER UTAH

DIS- SPECIFIC CONDUCT- NUMBER	STATION NAME	WATER YEAR	SOLVED SOLIDS		pH	TEMPER- ATURE	RESIDUE at 180 TOTAL	CAL- CIUM DISSOLVED	MAG- NESIUM	SOD- IUM SEDIMENT	POTA- SIUM	CHLO- RIDE	SUL- FATE	BI-		IRON							
			ANCE (micro- TOTAL	deg. C										Ca	Mg	Na	K	Cl	SO ₄	HCO ₃	Fe	Mn	Mn
mohs)	CARBONATE (units)	(deg. C)																					
09314500 at Woodside	Price River	1975-76 Max.	Min. 2,200 4,950	8.0	8.2 26.5	0 4,830	1,070 310	170 250	85 730	230 12.0	7.0 78	31 2,000	1,000 330	260 -	- -								
1976-77 Max.	Min. 6,950	1,370 8.7	7.4 29.0	0 6,770	1,150 400	220 350	16 1,100	77 15.0	7.0 130	15 4,300	600 570	170 510,000	440 70	10 16,000	- 110								
1977-78 Max.	Min. 6,090	1,140 8.7	7.6 26.0	0 4,990	1,290 330	110 290	79 760	190 13.0	4.0 100	22 3,100	640 450	40 18,000	10 20	10 860	90 60								
1978-79 Max.	Min. 6,540	1,110 8.4	8.0 21.5	- 6,240	822 250	83 320	51 990	110 17.0	3.4 110	17 3,700	390 500	240 46,000	280 -	- 1,300	10 20								
1979-80 Max.	Min. 5,510	1,090 8.7	8.0 23.0	0 5,660	761 -	- -	- -	- -	- -	- \$20	270 63,000	- -	0 2,600	- 10									
1980-81 Max.	Min. 4,480	2,720 8.3	8.0 24.0	0 3,860	2,070 250	130 230	130 640	300 12.0	7.2 96	52 2,500	1,300 330	- -	- 180	- -									
1981-82 Max.	Min. 4,080	1,170 8.3	8.0 23.5	0 2,880	830 240	82 210	53 530	97 8.9	2.9 90	16 2,100	360 350	194 24,000	9,600 -	- 820	240 -								
1982-83 Max.	Min. 3,920	830 8.4	8.2 20.0	0 3,500	830 260	82 220	53 520	97 8.9	2.3 79	17 2,200	210 340	210 36,000	- -	- 960	- -								
09315000 at Green River	Green River	1975-76 Max.	Min. 450 1,030	8.1 8.7	0 26.0	276 704	41 82	19 35	30 110	30 3.3	1.0 35	7.7 300	110 270	150 -	570 32,000	60							
1976-77 Max.	Min. 1,520	530 8.7	7.7 29.0	0 1,210	335 190	49 43	15 110	44 7.0	2.1 33	15 670	150 300	160 330,000	1,300 190	0 7,600	30 20								
1977-78 Max.	Min. 1,070	300 8.5	7.9 28.5	0 756	212 81	33 39	13 120	33 3.5	1.0 38	7.1 350	69 270	190 21,000	1,700 40	10 630	50 10								
1978-79 Max.	Min. 1,240	300 8.5	8.0 28.0	0 852	273 87	35 42	15 110	29 9.5	- 41	8 390	86 330	- 19,000	830 120	0 500	40 8								
1979-80 Max.	Min. 1,310	320 8.5	7.6 27.0	0 798	214 85	29 37	12 110	21 5.0	1.5 38	7.4 410	70 260	130 39,000	2,000 40	<10 1,100	50 10								
1980-81 Max.	Min. 1,200	320 8.3	7.8 26.0	0 852	273 82	47 41	19 110	50 3.7	1.8 40	14 350	160 190	110 27,000	1,200 30	<10 880	40 10								
1981-82 Max.	Min. 1,060	290 8.4	8.0 27.5	0 749	196 82	29 40	10 100	19 3.3	0.6 37	6 320	60 180	90 31,000	10,000 20	5 840	210 6								
1982-83 Max.	Min. 960	400 8.4	8.0 25.0	0 584	494 69	30 32	15 76	29 -	- 25	9.3 270	98 104	111 -	- 31	6 -	- 130								

Notes: Station locations: See Figure 4 (Price River Drainage Basin.
determinations. pH: field determinations.

Constituents : in mg/L, except manganese and iron, which are in micrograms/L.

Specific Conductance: field

IV. IDENTIFY HYDROLOGIC CONCERNS

The CHIA is based on the best currently available data and is a prediction of mining related impacts to the hydrologic balance outside of the specific permitted coal mine areas. To verify that conditions remain within acceptable limits the mine operator is required to monitor water quality and quantity as part of the permit requirements. The plans for monitoring are set forth in the Mining and Reclamation Plans (MRP) for the Centennial Project and the Soldier and Dugout Canyon Mines and have been determined adequate by The Division to meet regulatory requirements. If monitoring results show significant departures from the values established in the MRP's and in this CHIA or exceed UPDES discharge requirements, remedial actions are provided for by SMCRA.

Water quality standards for surface waters in the State of Utah are found in R317-2, Utah Administrative Code (UAC). The standards are intended to protect the waters against controllable pollution. Waters, and the applicable standards, are grouped into classes based on beneficial use designations. The Utah Division of Water Quality of the Department of Environmental Quality has classified surface waters in the Book Cliffs Area II CIA as:

- M 2B - protected for recreational uses except swimming,
- M 3C - protected for non-game fish and aquatic life, and
- M 4 - protected for agricultural uses.

General hydrologic concerns include changes of flow rates and chemical composition that could physically affect the off-permit hydrologic balance. Changes to the existing hydrologic regime or balance need to be limited in order to prevent economic loss to existing agricultural and livestock enterprises, prevent significant alteration to the channel size or gradient, and maintain adequate capacity for existing fish and wildlife communities. The basis for the limiting value of a parameter may differ according to specific site conditions.

Sediment is a common constituent of ephemeral stream flow in the western United States. The quantity of sediment in the flows affects stream-channel stability and most uses of the water. Excessive sediment deposition is detrimental to existing aquatic and wildlife communities. Large concentrations of sediment in streamflow may preclude use of the water for irrigating crops because fine sediment tends to reduce infiltration rates in the irrigated fields, and the sediment reduces capacities of storage facilities and damages pumping equipment. Mean sediment load is the indicator parameter for evaluating the sediment hazard to stream-channel stability and irrigation.

The concentration of dissolved solids is commonly used to indicate general water quality with respect to inorganic constituents. The quality of water from underground sources reflects the chemical composition of the rocks through which it passes. That quality may be degraded by intrusion of poorer quality water from wells or mines, by leakage from adjoining formations, or by recharge through disturbed materials. Ground water discharging from seeps and springs is used by wildlife and livestock. The state standard for TDS for irrigation of crops and

stockwatering (Class 4) is 1,200 mg/L.

The Utah Department of Environmental Quality, Division of Water Quality can authorize a coal mine to discharge into surface waters under the Utah Pollutant Discharge Elimination System (UPDES). The Dugout Canyon Mine has four UPDES permitted discharge points, one each to discharge from the sediment ponds at the minesite and the waste rock site, one to discharge from a 30-gallon holding tank for mine water, and one to discharge directly from underground sumps to Dugout Creek. The Soldier Canyon Mine has had four and currently has three UPDES permitted discharge points. UPDES permits for both mines contain site-specific limitations on TDS, total suspended solids, total settleable solids (for discharges resulting from precipitation events), total iron, oil and grease, and pH. There is no limit on flow but it is to be measured monthly at Dugout Canyon and twice monthly at Soldier Canyon. Additionally, there can be no more than a trace amount of visible sheen, floating solids, or foam and no discharge of sanitary waste or coal process water.

Macroinvertebrates are excellent indicators of stream quality and can be used to evaluate suitability of a stream to support fish and other aquatic life. Baseline studies of invertebrates (Lines and Plantz, 1981; Waddell, 1982; and USGS 1980, 1981, and 1982) provide standards against which actual conditions in Coal, Soldier, and Dugout Creeks can be evaluated if desired. Price and Plantz (1987) summarized invertebrate data.

Parameters that may have a reasonable possibility of affecting the hydrologic systems are included in routine water quality monitoring of the mine operations. Utah water quality standards exist for numerous parameters other than those already mentioned above, but at this time there is no evidence or reason indicating they are of concern or have a reasonable potential to affect the hydrologic balance of the CIA. Review of monitoring results by the mine operators and The Division will identify concerns or problems and generate revisions of the mine operations to mitigate those concerns or problems.

Water users have expressed concerns that water intercepted underground may be discharged into a watershed other than the one where the ground water was originally destined. A mine may divert water underground and discharge to the surface, and the Utah Coal Mining and Reclamation Act and rules require material damage to the hydrologic balance outside of a permit area to be prevented and disturbance to the hydrologic balance within the permit area minimized (R645-301-731.214.1). Furthermore, any state-appropriated water affected by contamination, diminution, or interruption resulting from underground mining must be replaced (R645-301-731.530). The Division evaluates a mine's Probable Hydrologic Consequences Determination (PHC) and updates the CHIA prior to permitting, and reviews water monitoring data during mining and post-mining reclamation to determine if adverse hydrologic impacts, as defined by the rules, can be demonstrated. Underground mining may result in some diversions of intercepted ground water into drainages that are not topographically within (above) the area where the water was encountered. The PHCs of mines in the Book Cliffs Area II CIA have demonstrated that water that is projected to be intercepted is mostly ancient and therefore hydrologically isolated from springs, seeps, and streams. If it is subsequently demonstrated that mining has caused or will cause a diminution, contamination, or interruption of an appropriated

IDENTIFY HYDROLOGIC CONCERNSBook Cliffs Area II

water right or a material impact to the hydrologic balance either within or outside of the permit area, the permittee will be required by the Division to address means of minimizing the impact and replacing any appropriated water rights.

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IDENTIFY HYDROLOGIC CONCERNS

V. IDENTIFY RELEVANT STANDARDS

RELEVANT STANDARDS

Flow:

There is no standard for flow in the Soldier Canyon Mine or Dugout Canyon Mine UPDES permits, nor in Utah water quality standards. UPDES discharge is to be recorded twice monthly at both the Soldier Canyon, and Dugout Canyon Mines. Characteristics such as stream morphology, vertebrate and invertebrate populations, and water chemistry can be affected by changes in flow and therefore can provide an indirect standard for flow.

Oil and Grease:

There is no State water quality standard for oil and grease, but the UPDES permit limit for the Soldier and Dugout Canyon Mines is a daily maximum of 10 mg/L; only one grab sample a month is required, except a grab sample must be taken immediately if there is a visible sheen. A 10 mg/L oil and grease limit does not protect fish and benthic organisms from soluble oils such as those used in longwall hydraulic systems, and UDWR has recommended soluble oils be limited to 1 mg/L (Darrell H. Nish, Acting Director UDWR, letter dated April 17, 1989 to Dianne R. Nielsen, Division Director).

Total Dissolved Solids (TDS) concentrations:

The concentration of dissolved solids is commonly used to indicate general water quality with respect to inorganic constituents. There is no state water quality standard for TDS for Classes 1, 2, and 3, but 1,200 mg/L is the limit for agricultural use (Class 4). The Soldier Canyon Mine UPDES permit limits instantaneous TDS concentration to 1,200 mg/L, determined by two grab samples a month. The total amount of dissolved solids discharged from all Soldier Canyon Mine operations is limited to 5 tons per day, determined by the twice monthly measurements of flow and TDS. TDS discharged from Dugout Canyon Mine is limited to 500mg/L as a 30-day average. If that is exceeded, a 1 ton per day limit applies. Canyon Fuel is also participating in a salinity offset program, as approved by DWQ.

pH: Allowable pH ranges are 6.5 to 9.0 under the UPDES permits for both mines and also under State water quality standards for all Classes of waters.

Total Suspended Solids (TSS) and Settleable Solids:

There is no State water quality standard for solids in the water, but an increase in turbidity is limited to 10 NTU for Class 2A, 2B, 3A, and 3B waters and to 15 NTU for Class 3C and 3D waters. UPDES permits for both mines allow a daily maximum of 70 mg/L TSS but limit the 30-day average to 25 mg/L. TSS is determined from two grab samples a month at both mines.

All samples collected during storm-water discharge events, at both Soldier and Dugout Canyon Mines are to be analyzed for settleable solids. Samples collected from increased discharge, overflow, or bypass that is the result of precipitation that does not exceed the 10-year, 24-hour precipitation event can comply with a settleable solids standard of 0.5 mL/L daily maximum rather than the TSS standard, although TSS is still to be determined. If the increased discharge, overflow, or bypass is the result of precipitation that exceeds the 10-year, 24-hour precipitation event, then neither the TSS nor settleable solids standard applies, although all sampling and analysis requirements still apply.

Iron and Manganese:

The Soldier Canyon and Dugout Canyon UPDES permits allow a daily maximum of 1.0 mg/L total iron, which is based on an assumption that total and dissolved iron concentrations are the same. At both mines, grab samples are taken twice a month to determine iron concentration.

With approval from the Division of Water Quality, Soldier Canyon Mine can discharge up to 2 mg/L total iron under certain circumstances, which include maintaining dissolved iron at or below 1 mg/L. State water quality standards allow a maximum of 1 mg/L (1,000 µg/L) dissolved iron in Class 3A, 3B, 3C, and 3D waters, with no standard for Class 1, 2, and 4 waters.

Monitoring of total manganese is required by SMCRA and the Utah Coal Mining rules, but there is no UPDES or water quality standard for either total or dissolved manganese.

Macroinvertebrates:

Macroinvertebrates are excellent indicators of stream quality and can be used to evaluate suitability of a stream to support fish and other aquatic life. Baseline studies of invertebrates (Lines and Plantz, 1981; Waddell, 1982; and USGS 1980, 1981, and 1982) provide standards against which actual conditions in Coal, Soldier, and Dugout Creeks can be evaluated if desired.

Price and Plantz (1987) summarized invertebrate data. There are no current plans to monitor invertebrate populations in the streams of the CIA.

Utah water quality standards exist for numerous parameters other than those mentioned above, but at this time, there is no evidence indicating, or reason to believe, that those parameters are of concern in the Book Cliffs Area II CIA. The Division's directive Tech-004 (July 1, 1997) recommends additional parameters for routine monitoring and most of those Division recommended parameters are included in the water quality monitoring of the mine operations.

MATERIAL DAMAGE

Material damage to the hydrologic balance would possibly manifest itself as an economic loss to the current and potential water users, would result in quantifiable reduction of the capability of an area to support fish and wildlife communities, or would cause other quantifiable adverse change to the hydrologic balance outside the permit area. The basis for determining material damage may be found to differ from site-to-site within the CIA according to specific site conditions. Surface and ground-water concerns have been identified for CHIA evaluation.

Parameters for surface-water quantity and quality

The potential material-damage concerns this CHIA focuses on are changes of surface flow rates, and chemical composition that would physically affect the off-permit stream channel systems as they presently function; and that would affect aquatic and wildlife communities and agricultural and livestock production. Therefore, criteria are intended to identify changes in the present discharge regime that might be indicators of economic loss to existing agricultural and livestock enterprises; of significant alteration to the channel size or gradient; or of a loss of capacity to support existing fish and wildlife communities. In order to assess the potential for material-damage to these elements of the hydrologic system, the following indicator parameters were selected for evaluation at each evaluation site: low-flow discharge rate, TDS, and sediment load.

The surface-water concerns will be evaluated at 25-2 in the Coal Creek drainage; G-1*, G-2*, G-5, G-6, G-7, G-8, G-9, and G-10* in the Soldier Creek drainage; DC-1, DC-2, DC-3, DC-4, and DC-5 in the Dugout Creek drainage; PC-1a and PC-2 in the Pace Creek drainage; and RC-1 in the Rock Creek drainage. Locations are identified on Plate 2. (* G-1 and G-2 are no longer monitored, monitoring of G-10 will resume in the quarter that the Soldier Canyon mine portals are reopened for active mining.)

Low-Flow Discharge Rate

Measurements provided by mine operators are generally of instantaneous flow and provide some indication of long-term trends, but are probably no more accurate; either individually, or as a whole than the "poor" classification of USGS measurements. In the Wasatch Plateau, Waddell and others (1981) found that correlating three years of low-flow records (September) at stream sites against corresponding records from long-term monitoring sites would allow the development of a relationship that could be used to estimate future low-flow volumes at the stream sites within a standard deviation of approximately 20%. Ten years of record reduced the standard deviation to 16% to 17% and 15 years of data to about 15%. This relationship has not been demonstrated for streams in the Book Cliffs; however, it indicates that a change in low-flow rates of less than 15% to 20% probably would not be detectable. A 20% decrease in the low-flow rate will provide a threshold indicator that decreased flows are persisting and that an evaluation for material damage is needed.

Monitoring of low-flow discharge rates will also provide a means to evaluate effects of mine discharge on the receiving streams. Mine discharge water is monitored at Soldier Canyon Mine UPDES discharge points 001 and 003, and discharge from the sedimentation pond at 002. At Dugout Canyon Mine, discharge point 001 monitors the direct discharge from the mine, point 002 monitors the sediment pond at the minesite, point 003 monitors the discharge from a 30-gallon tank at the minesite, and point 004 monitors the discharge from the sedimentation pond at the waste-rock site. The potential for material damage by mine discharge water is tied to the effect on the flow in the receiving streams.

Total Dissolved Solids (TDS)

The concentration of dissolved solids is commonly used to indicate general water quality with respect to inorganic constituents. Ground water discharging from seeps and springs is used by wildlife and livestock. Because wildlife and livestock use is the designated postmining land use, established dissolved solids tolerance levels for livestock have been adopted as the thresholds beyond which material damage may occur. The state standard for TDS for irrigation of crops and stock watering (Class 4) is 1,200 mg/L. If TDS concentrations persistently exceed 1,200 mg/L, it will be an indication that evaluation for material damage might be needed.

At G-5, TDS has approached 1,200 mg/L several times and exceeded it twice (1,220 mg/L and 1,556 mg/L). Only six samples have been analyzed for TDS at G-10, which monitors a stream that flows across Mancos Shale, but TDS has been consistently high, averaging 1,388 mg/L and exceeding 1,200 mg/L five times (13,40, 1,520, 1,540, 2,530, and 2,710 mg/L). Several permitted discharges to Soldier Creek from UPDES points 001 and 003 have exceeded 1,200 mg/L also. So far there has been no evidence these concentrations above 1,200 mg/L have caused material damage to the hydrologic balance.

Sediment Load

Sediment is a common constituent of ephemeral stream flow in the western United States. The quantity of sediment in the flows affects stream-channel stability and most uses of the water. Excessive sediment deposition is detrimental to existing aquatic and wildlife communities. Large concentrations of sediment in streamflow may preclude use of the water for irrigating crops because fine sediment tends to reduce infiltration rates in the irrigated fields, and the sediment reduces capacities of storage facilities and damages pumping equipment. Sediment load measurement error is, at a minimum, the same as the flow measurement error because sediment load is directly dependent on flow and in practice cannot be measured more accurately than the flow.

TSS is the indicator parameter initially chosen for evaluating the sediment hazard to stream-channel stability and irrigation. Threshold values have initially been set as the greater of one standard error above the baseline mean TSS value or 120% of the baseline mean TSS value (by analogy with the low-flow discharge rate measurement accuracy and assuming that the error in TSS will contribute equally with the error in flow when determining mean sediment load). If TSS concentrations persistently exceed these threshold values it will be an indication that evaluation for material damage from sediment load in the streams might be needed.

Parameters for ground-water quantity and quality

The potential material-damage concerns of this CHIA are intended to limit changes in the quantity and chemical composition of ground-water to magnitudes that: will not cause economic loss to existing or potential agricultural and livestock enterprises; will not degrade domestic supplies, would not cause structural damage to the aquifers; and will maintain adequate capacity for existing fish and wildlife communities.

To assess the potential for material damage to these elements of the ground-water hydrologic system, the following indicator parameters were selected for evaluation: seasonal flow from springs and TDS concentration in spring and mine-discharge water.

Ground-water concerns will be monitored at spring S25-1 in the Coal Creek drainage; springs 4*, 5*, 8*, 10*, 23*, 24*, SC-14, and SP-20 and wells 6-1, 32-1*, and 10-2 in the Soldier Creek-Fish Creek drainage; springs SC-65, and SC-100 and well 11-2 in the Dugout Creek drainage; springs SC-116, 203, 227, and 259 and well 24-1 in the Pace Creek drainage; spring 200 in the left fork of the Rock Creek drainage, and spring 260 in the Cow Canyon drainage. Locations are identified on Plate 2. (* 4, and 8 are no longer monitored, monitoring of 5, 10, 23, 24, and 32-1 will resume in the quarter that the Soldier Canyon mine portals are reopened for active mining.)

Seasonal flow from springs

Maintain potentiometric heads that sustain average spring discharge rates, on a seasonal basis, equal or greater than 80% of the mean seasonal baseline discharge, in other words baseline minus 20% probable measurement error. The 20% measurement error is based on analogy with the accuracy of measuring low-flow surface discharge rates. A 20% decrease in flows, determined on a seasonal basis, will indicate that decreased flows are probably persisting and that an evaluation for material damage is needed.

TDS concentration

The concentration of total dissolved solids is commonly used to indicate general water quality with respect to inorganic constituents. The quality of water from underground sources reflects the chemical composition of the rocks it passes through. Ground-water quality may be degraded by intrusion of poorer quality water from wells or mines, by leakage from adjoining formations, or by recharge through disturbed materials. Ground water discharging from seeps and springs is used by wildlife and livestock, and those are the designated postmining land uses. There is no water quality standard for TDS for aquatic wildlife. The state standard for TDS for irrigation of crops and stockwatering (Class 4) is 1,200 mg/L. If TDS concentrations persistently exceed 1,200 mg/L it will be an indication that evaluation for material damage might be needed..

Five samples were collected at Spring 6 in 1995 and 1996 that had consecutively increasing TDS and sulfate concentrations, and TDS in the final two samples exceeded 1,200 mg/L. TDS concentrations at in-mine monitoring well UG-11E have been consistently close to, and occasionally have exceeded, 1,200 mg/L. There was also a single sample from Spring 10 in which TDS exceeded 1,200 mg/L. So far there has been no evidence these concentrations above 1,200 mg/L have caused material damage to the hydrologic balance. Samples from the wells at the proposed Soldier Canyon Mine waste rock disposal site consistently had TDS concentrations in the range of 6,000 mg/L to 14,000 mg/L.

VI. ESTIMATE PROBABLE FUTURE IMPACTS OF MINING ACTIVITY

GROUND WATER

Dewatering and subsidence related to mining have the greatest potential for affecting ground-water resources in the CIA.

Dewatering

Underground mining removes the support to overlying rock, which can cause caving and fracturing of the overburden. In most mining areas, it is unlikely that fractures will reach shallower perched aquifers because of the thickness of the overburden, but in areas where fracturing is extensive, subsidence induced caving and fracturing can create conduits that allow ground water to flow into the mine. Dewatering caused by fracturing may decrease aquifer storage and ground-water flow to streams and springs (Figure 6). Water quality downstream from the mines could improve because water being discharged from coal mines in the Book Cliffs and Wasatch Plateau is often of better quality than natural spring flow or base flow.

Total ground-water storage above the Gilson Seam at the Soldier Canyon Mine has been estimated by Canyon Fuel Company to be 490,000 ac-ft, assuming an average saturated thickness of 1,000 feet, an area of 4,900 acres, and a storage coefficient of 0.10 (Soldier Canyon Mine MRP p. 7-28). Canyon Fuel Company has made no estimate for the Dugout Canyon Mine: if fully developed as planned, the Dugout Canyon Mine will be larger than the Soldier Canyon Mine; nevertheless, the volume of ground-water stored above the Dugout Canyon Mine should be of a magnitude similar to that stored above the Soldier Canyon Mine.

Average ground-water recharge for the 10.4 square miles of the Soldier Canyon Mine permit area is estimated to be 740 ac-ft using 9% as the average infiltration factor (Soldier Canyon Mine MRP Table 7.24-3). Because of hydrologic isolation between the Blackhawk Formation and the surface, Canyon Fuel Company does not foresee an increase in recharge rate at the surface caused by dewatering of deeper strata. A notable or measurable increase in recharge is also unlikely because recharge is generally available only for a few months during spring snowmelt and for very brief periods during summer thundershowers. During these seasonal, relatively short events the soils reach saturation quickly and reject most available water. Recharge and discharge relations for the Dugout Canyon area are discussed on page 7-30 of the Dugout Canyon Mine MRP: no estimate of recharge volume is made, but it should be similar in magnitude to that at Soldier Canyon.

Most water entering the Soldier Canyon Mine comes through leaks in the mine roof. Average annual flow into the Soldier Canyon Mine between 1985 and 1991 increased from about 160 acre-feet per year to approximately 1,000 acre-feet, with an average of 460 acre-feet per year (Soldier Canyon Mine MRP p. 7-151). Based on Soldier Canyon Mine Annual Reports, Mayo and Associates (Dugout Canyon Mine MRP Appendix 7-3, p. 17) calculated that the average

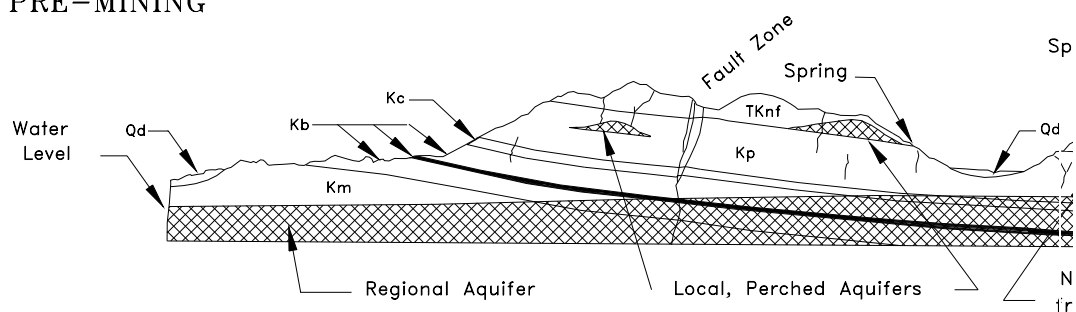
annual flow into the mine between 1988 and 1994 was approximately 220,000,000 gallons per year (420 gpm or 680 acre-feet per year). Canyon Fuel Company's estimate of average groundwater interception due to continued mining activities at the Soldier Canyon Mine (Soldier Canyon Mine MRP, p. 7-28) is 460 acre-feet per year (280 gpm or 150,000,000 gallons per year). The Blackhawk Formation is probably saturated in most areas (Waddell and others, 1986, p. 41) and the Dugout Canyon Mine was expected to produce water at a rate similar to the Soldier Canyon Mine; however, had been no discharge from the mine and no reports of significant inflows until 2002, when Canyon Fuel discovered a large amount of water stored in an abandoned mine adjacent to the Dugout Canyon workings (Knight-Ideal Mine). For safety reasons, the Mine Safety and Health Administration (MSHA) required Canyon Fuel to dewater the abandoned workings as quickly as possible. This resulted in discharges ranging from 1565 to 1750 gpm. The Permittee has not reported any significant inflows to date.

There are several places within the MRP text that indicate that there are no acid- or toxic-forming materials within the Dugout Canyon Mine permit area. The text locations include Chapter 6, Geology, Chapter 5, Engineering, and Chapter 7, Hydrology. It appears this is not a problem at this site.

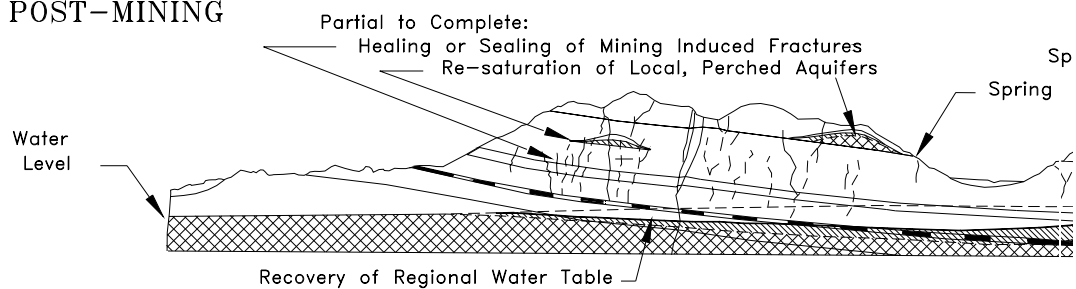
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Subsidence

PRE-MINING



POST-MINING



Subsidence impacts in the Wasatch Plateau and Book Cliffs coal fields are largely related to extension and expansion of existing fracture systems and upward propagation of new fractures (Figure 6). Inasmuch as vertical and lateral migration of water appears to be partially controlled by fracture conduits, readjustment or realignment in the conduit system will inevitably produce changes in the configuration of ground-water flow. Potential changes include decreased flow through existing fractures that close, increased flow rates along existing fractures that open further, and the diverting of ground-water flow along new fractures or within newly accessible permeable lithologies. Subsurface flow diversion may cause the depletion of water in local aquifers and loss of flow to springs. Increased flow rates along fractures could potentially improve water quality by reducing ground-water residence time.

Subsidence surveys have been done at Soldier Canyon Mine on an annual basis since 1988 using ground surveying supplemented with photogrammetric methods if needed. Annual subsidence reports are provided to The Division. Annual reports for 1988, 1989, 1992, 1993, 1994, 1995, and 1996 indicate no subsidence over the current Soldier Canyon Mine permit area (indicated elevation changes are within the limit of accuracy of the survey method). Reports for 1997, 1998, and 1999 indicate a small amount of subsidence, less than 2 feet, may have occurred at one monitoring point. The Castlegate Sandstone and thick overburden are responsible for reduced surface subsidence. Mining has occurred beneath 500 to 2,000 feet of overburden and mining is projected to be done beneath up to 2,250 feet of cover.

In the eastern part of the Centennial project that is within the CIA, longwall mining is planned for the Gilson and Aberdeen Upper "A" Seams and continuous mining for the Lower Sunnyside Seam. Overburden thicknesses over these areas are from 400 to 1,200 feet. A large area of the Gilson Seam and a smaller area of the Lower Sunnyside Seam have already been mined in this area, with overburden ranging from very thin near the outcrop to 1,200 feet (Plates 26-29, Centennial Project MRP). As of 2004, Centennial reported no evidence of subsidence at the surface.

As of 2004, mining at the Dugout Canyon Mine had produced <1 foot of upheave at 21 of 35 monitoring points, and a maximum of 3.5 ft, according to Annual Reports. Mining is currently planned for both the Rock Canyon and Gilson Seams, but mining of both seams in one place is planned for only a small area near the portals. Overburden thickness will generally be less than 1,600 feet. Based on experience in the region and the work of Dunrud (1976), DeGraff (1978), and DeGraff and Romesburg (1981), surface effects of subsidence are expected to be limited to tension cracks that will heal with time. The potential for these tension cracks to affect the subsurface and surface hydrologic regimes is not considered significant by Canyon Fuel Company.

SURFACE WATER

Changes in flow volume and in water quality have the greatest potential for impacting surface-water resources in the CIA.

PROBABLE FUTURE IMPACTS

Water Quality

The quality of the local surface waters can be affected by two basic processes. First, the runoff from the operator's disturbed lands and waste piles could increase sediment concentrations and alter the distribution and concentration of dissolved solids in the receiving streams. This potential for inducing water quality changes in Soldier and Dugout Creeks has been fully recognized, and the runoff control plan established for the mines is adequate in anticipating, monitoring and mitigating the potential impacts.

The second potential cause of surface water quality changes is related to the location and chemistry of ground-water discharges, both from the mines and from springs and baseflow. As discussed by Waddell and others (1986, p. 28), discharge of ground water from the Flagstaff Limestone sustains perennial flow of Soldier Creek following spring and early summer snowmelt. Discharge from the Flagstaff during the fall and winter is greatly reduced and discharge from underlying formations, mainly the Blackhawk, sustains the stream flow. Dugout Creek originates at a similar altitude. The geology is also similar except that Flagstaff Limestone is thinner and has less surface exposure than at Soldier Canyon.

TDS concentration in ground water from the Flagstaff Limestone is generally lower than that in ground water from underlying formations. Stream flow in the upper segment of Pine Creek contains baseflow from the Flagstaff Limestone. In water-years 1979 and 1980 TDS was 200 to 300 mg/L and magnesium, calcium and bicarbonate ions dominated. In contrast, the lower reaches of Soldier Canyon receive baseflow from the North Horn and Blackhawk Formations. In 1979 and 1980 TDS ranged from about 300 to 700 mg/L. At low flow the dominant ions were sodium, magnesium, sulfate, and carbonate, but at high flow, calcium and bicarbonate dominated (Waddell and others, 1982; 1986) because ground water from the Blackhawk was contributing a smaller portion of total flow and therefore had a smaller effect on the quality of the stream water.

In 1989 Soldier Canyon Mine requested an increase in the daily limit on dissolved solids that could be discharged under the UPDES permit and Colorado River Salinity Standards because the inflow of ground water to the mine had increased to the point that dissolved solids flowing into the mine with the water exceeded 1 ton per day, which was the mine's UPDES discharge limit at that time. The current UPDES permit allows for Soldier Canyon Mine to discharge up to 5 tons of dissolved solids per day into Soldier Creek (total from all permitted outfalls). Maximum allowed TDS concentration is 1,200 mg/L. TDS concentrations have remained generally between 800 and 1,000 mg/L in recent years, but concentrations exceed 1,200 mg/L occasionally. In water discharged from the mine, oil and grease occasionally exceeds the UPDES limit.

At and below the point of mine discharge into Soldier Creek, during periods of low flow, there is little apparent variation between water quality of the stream and the mine discharge. During dry periods the mine discharge produces most of the stream flow. During periods of high flow, the effects of mine discharge to the stream are negligible with respect to sediment transport and water chemistry.

TDS discharge limits (UPDES Permit) for the Dugout Canyon Mine are 500mg/L as a 30-day average. If that is exceeded, a 1 ton per day limit applies. Canyon Fuel is also participating in a salinity offset program, as approved by DWQ. Continuation of Canyon Fuel Company's monitoring programs at the two mines will verify water consumption and discharge estimates.

Waddell and others (1986) describe the streambed characteristics of Soldier Creek in some detail. The stream appears to be naturally saturated with respect to calcite and the sediments in the bed of Soldier Creek become cemented with carbonate precipitates during the low-flow period in fall and winter. A new benthic environment is created when sediment is added or redistributed by the spring runoff. The diversity of benthic invertebrates varies seasonally because of these processes that alternately cement and disturb the sediment.

The only current surface water monitoring in the Coal Creek drainage is at 25-2 on Hoffman Creek. Surface and ground-water samples were collected at several locations in the upper Coal Creek drainage in January 1981 by the operators of the Centennial mines: the Centennial project does not discharge into Coal Creek or other surface waters in the CIA. USGS station 09313965 on Coal Creek, just below the Hoffman Creek confluence, was monitored periodically for water quality and flow between September 1977 and September 1981, but no monitoring or sampling was done during the months December through April.

Surface water monitoring locations are shown on Plate 2. G-1 through G-10 are sites that have been or will be monitored by Canyon Fuel Company during operation and reclamation of the Soldier Canyon Mine. G-6 has replaced G-1 for monitoring water quality upstream of the disturbed area; monitoring at G-1 was discontinued after two years of baseline data were collected at G-6. G-6 should more accurately indicate the condition of surface water entering the disturbed area because G-1 was far from the disturbed area and factors other than mining could have influenced the water quality between G-1 and the disturbed area. Monitoring of G-5 will continue to provide water quality data below the disturbed area.

G-3 and G-4 were monitored up to 1986 and 1985, respectively. Plate 2 shows their locations as near as can be determined from available information. G-7 is at approximately the same location as G-4, and G-9 appears to be slightly upstream of G-3. G-8 and G-9 were temporary sites used to determine the effects of mining on Pine Creek and the relationship between the Blackhawk Formation and creek flows. Monitoring at G-2, G-8, and G-9 was dropped in 1999, after mining ceased beneath the Pine Canyon drainage. G-7 is also a temporary site that will be monitored during wet and dry years as defined in the Soldier Canyon Mine MRP. Site G-10 has been added to monitor surface flow from part of the Alkali Tract (p. 7-166, Soldier Canyon Mine MRP).

At the Dugout Canyon Mine, surface water is monitored at DC-1 below the disturbed area; at DC-2, DC-3, DC-4, and DC-5 upstream of the disturbed area; at FAN, PC-1a and PC-2 in Pace Canyon; at RC-1 in Rock Canyon; and at SS-1 and SS-2 at the waste-rock site.

Baseline data were collected at DC-1 between 1976 and 1981. Quarterly baseline data were collected at DC-1, DC-2, and DC-3 in 1997 and 1998 for the Dugout Canyon Mine permit application.

Canyon Fuel Company established monitoring site PC-1a in 1999 to replace PC-1. Canyon Fuel collected baseline parameters at RC-1, PC-1a and PC-2 from 1999 through 2002, after which they switched to monitoring operational parameters.

Water quality at the Dugout Canyon Mine is similar to that at the Soldier Canyon Mine.

Dugout Canyon Mine Sediment Control

The Dugout Canyon Mine MRP describes specific methods used to control sediment flow into Dugout Creek.

There is one sedimentation pond at the Dugout Canyon Mine. This pond will be used throughout the mining operations and reclamation. It is designed to contain more than five years of sediment accumulation based on the Universal Soil Loss Equation (USLE) plus the water volume resultant from the 10-year, 24-hour storm event. Both undisturbed area and disturbed area drainages are treated by the sedimentation pond. Sediment removal will be done when the sediment level reaches 60% of pond capacity. The pond is equipped with a dewatering device and a spillway. The appropriate 25-year, 6-hour event was used to size the combined primary and emergency spillways.

A sediment trap serves as the main sediment control at the Pace Canyon Fan Portal.

There is one undisturbed ditch that routes water from the southern slopes past the disturbed area. Undisturbed drainages on the northwest side of the disturbed area are treated by the sediment pond. The result is minimum sediment contribution to Dugout Creek itself.

The sedimentation pond will be retained for as long as practical during reclamation and will be removed near the end of the reclamation process. Once backfilling and grading operations proceed to the location of the pond, it will be removed. When an area no longer properly drains to the sediment pond, silt fence will be installed along the base of the slope to create alternate sediment control areas (ASCA). The silt fences will be utilized until vegetation is successfully established to control erosion.

On a temporary basis, straw-bale dikes may also be installed as necessary to control localized erosion prior to the establishment of revegetation. Locations of the straw-bale dikes will be selected to reduce sediment contributions to runoff based on field observations. Straw-bale dikes will be installed by keying the bales into the ground.

At the Dugout Canyon Mine, ASCAs are designated for four areas that cannot report to the sediment pond. Three of these are around the water tanks and along the road to the water tanks. Sediment control is by silt fences or straw bale dikes along the road, and gravel surfacing

and partial reclamation are used around the water tanks. The fourth ASCA is a small portion of the primary haul road adjacent to the sedimentation pond, with paving providing the sediment control.

Culverting of Dugout Creek

On March 6, 1998 the BLM sent a letter to the Utah Division of Water Rights indicating several concerns on the Dugout Mine stream alteration permit and the culverting of Dugout Creek through the minesite. The stream alteration has been determined not to be a significant problem for the following reasons.

1. The geologic formation in the disturbed area is the Blackhawk Formation, which consists dominantly of sandstone, siltstone, and shale. The Blackhawk is underlain by the Mancos Shale. There are only a few faults in the entire permit area. Two vertical joints have been mapped in the disturbed area where the culvert was placed (Anderson, 1983). Dip is 6 degrees to the north: the stream flow is to the southwest, or updip. There is little likelihood this is an area of recharge to aquifers.
2. While there is alluvium in the stream, it is too thin or sparse in the mine area to be mapped on the geologic map. About 1500 feet downstream from the disturbed area Quaternary alluvium and pediment gravels are mapped. There is little likelihood alluvial aquifers are being recharged in this area.
3. The Dugout Creek drainage area, above its confluence with Grassy Trail Creek (near Utah Highway 6), is over 43 square miles or 27,520 acres, as compared to the disturbed area of 10.4 acres. Similarly, the culvert occupies 2,000 feet of the 9.5 miles of stream channel between the mine and Grassy Trail Creek. The disturbed portion of the watershed, and of the potential recharge area is minor.
4. Water will not be lost by passing through the culvert. The water is returned to the natural stream channel at the outlet, where it is available to recharge groundwater aquifers in the area (although there are no known aquifers in the area). There is no evidence to suggest that the reach of stream occupied by the culvert is of special significance to such recharge. Studies by Waddell and others (1986, p. 28), Price and Plantz (1987), and Mayo indicate that similar situations in nearby Soldier Creek result in streams gaining, not losing, water as they pass over the Blackhawk formation.
5. Prior to constructing the culvert, the USGS monitored site 09313985 at the lower end of what is now the Dugout Canyon Mine disturbed area. Unfortunately, no monitoring was done above the site to define whether the disturbed area was on a gaining or losing section of Dugout Creek. One set of observations, made at the DC-1 to DC-5 sites on August 27, 1997 (the driest time of year), showed the flows above and below the disturbed area to be the same.

Overall, the culverted reach of stream is of very minor consequence when compared to the recharge mechanism for springs that issue from the Mancos shale down gradient of the

Dugout Canyon Mine disturbed area, near the confluence with Grassy Trail Creek. Similarly, the streamflow in Dugout Creek is not expected to suffer any significant impacts.

Water Quantity

Water not used in the Soldier Canyon Mine or lost to evaporation is collected in an in-mine settling pond and discharged to Soldier Creek through UPDES 003, also identified as MW-2. The in-mine settling pond at the Soldier Canyon Mine reduces suspended solids. Waddell (1986, Table 6) estimated that discharge for December 1980 was only 15 ac-ft, approximately 100 gpm. Average daily discharge rates from 1985 to May 1998, taken from monthly Discharge Monitoring Reports (DMR) for UPDES 003, varied between 30,000 gpd (21 gpm) to 967,000 gpd (672 gpm). Maximum measured flow from DMRs during that period was 1,075,000 gallons per day (750 gpm); minimum flow was not reported on the DMRs. Average annual discharge was about 170,000,000 gallons per year (285 gpm). Daily discharge rates were greatest in 1991, annual discharge greatest in 1992 (Figure 5). Data for 1986 were not available. Coal production stopped in October 1998, and from June 1998 through June 2005 (when the Division completed this CHIA) there was no water discharged from the mine. Yearly coal production increased from 1985 to 1990, with production for 1989 through 1991 roughly double what was typical for the mine during most other years. Coal production was high in 1996 also, but there was no corresponding increase in water discharge (Table 1 and Figure 5). Ongoing monitoring will indicate total ground-water discharge due to mining.

Upon final termination of mining operations, discharge of ground water from the Soldier Canyon Mine to Soldier Creek will be discontinued and the mine will begin to flood. There will be an initial reduction in surface flow because of the loss of the mine discharge, but flow in Soldier Creek should remain perennial. However, surface flow may recover to pre-mining conditions if base flow to the stream is reestablished as the mine floods. The time required for mine flooding will depend not only on the rate of water inflow but also on the amount of caving and the void space remaining after caving. Complete flooding of the mine may never occur because flow out of the mine through the roof, floor, and ribs and into the surrounding rock will increase as flooding increases the hydraulic head within abandoned workings.

It is anticipated that discharge of water from the Dugout Canyon Mine operation will be similar to what has been observed or predicted to date at the Dugout and Soldier Canyon Mines. Dugout Creek has become perennial below the minesite. Upon termination of mining operations at the Dugout Canyon Mine, the mine will begin to flood and conditions can be expected to be similar to the Soldier Canyon Mine, except that Dugout Creek will return to intermittent flow, rather than perennial.

It has been determined that Soldier Creek loses water where it crosses the Price River Formation and Castlegate Sandstone (Waddell and others, 1982; 1986). Further gain-loss measurements are planned at G-6 and G-7 during “wet” and “dry” years (as defined in the MRPs). One purpose of the planned monitoring at DC-2, DC-3, DC-4, and DC-5 is to determine if a similar loss occurs on Dugout Creek. DC-4 and DC-5 will be used mainly to collect gain-loss hydrograph data, with limited analysis for water quality.

ALLUVIAL VALLEY FLOORS (AVF)

Based on the studies conducted by Sunedco Coal Company for the approved Sage Point-Dugout Canyon MRP, a negative determination has been made on the existence of unconsolidated streamlaid deposits holding streams and sufficient water to support agricultural activities within the mine plan area. A potential AVF exists downstream of the Soldier Canyon Mine along Soldier Creek.

VII. ASSESS PROBABLE MATERIAL DAMAGE.

Surface disturbance and discharge from the Soldier Canyon and Dugout Canyon Mines have not significantly degraded water quality in Soldier or Dugout Creeks. Sediment control measures have served to reduce contaminants and stabilize water quality at acceptable levels at the Soldier and Dugout Canyon Mines and at other mines in the Wasatch Plateau and Book Cliffs coal fields.

No AVF will be impacted during the first five year permit term by additional flow from increased mine water discharge.

FUTURE MINING

Increased rates of dewatering may, in the future, result in depletion of ground-water storage. Depletion of storage may terminate certain spring flows and base flow recharge to streams. Upon cessation of mining, mine water discharge to Soldier and Dugout Creeks will be discontinued. Mine flooding will probably result in reestablishment of the preexisting ground-water systems that, most likely, provided base flow to the streams.

Drainage from future surface disturbance will be managed through appropriate sediment controls. Future Soldier and Dugout Canyon mine discharges will be directed through sediment ponds.

At the termination of mining, downstream potential AVF's will experience decreased flow. The duration and extent of this impact cannot be accurately assessed at this time. However, flow rates may be partially to fully restored when the ground-water system is reestablished by flooding of the abandoned mines.

The operational designs for the Soldier Canyon Mine, Dugout Canyon Mine, and Centennial Project are determined, based on the information submitted in the mine plans and referenced literature, to be consistent with preventing damage to the hydrologic balance outside the mine plan areas.

Underground mining may result in some diversions of intercepted ground water into drainages that are not topographically within (above) the area where the water was encountered. If it is demonstrated that mining has caused or will cause a diminution, contamination, or interruption of an appropriated water right or a material impact either within or outside of the permit area, the permittee will be required by the Division to address means of minimizing the impact and replacing any appropriated water rights. Evaluations of PHCs and the preparation of this CHIA do not indicate that there is any evidence that such impacts will result from the proposed mining in the Book Cliffs Area II CIA. As a consequence, there is no reason to require operators to propose alternatives for disposing of the displaced water or other possible actions as part of the PAP.

VII. STATEMENT OF FINDINGS

The Division has found no evidence of material damage from the actual mining operations, nor a probability of material damage from actual or anticipated mining operations in the Book Cliffs Area II CHIA.

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